THE
POPULAR SCIENCE
MONTHLY.

OCTOBER, 1913

IMMIGRATION AND THE PUBLIC HEALTH

By Dr. ALFRED C. REED
NEW YORK CITY

I. The Nature of Public Health

THE age has happily passed when patriotism is measured in terms of human life sacrificed, and weighed in the balance of territorial or financial advantage. War has its heroes and mighty men who, fighting for man or cause, regardless of victory are accounted great. But the heroes and mighty men of peace who, for man and man's cause, fight the more terrible foes of ignorance, disease and public wrong, are coming to be accounted infinitely greater. No soldier opposing foreign foe was a truer patriot or died more nobly than did Dr. Thomas B. McClintic who, with no panoply of militarism, quietly and unfalteringly with his own life helped pay the price of the conquest of Rocky Mountain spotted fever last summer in the Bitter Root Valley of Montana.

Truly it is sweet to die for one's country. But even in the battles of peace the need of this sacrifice is rare. Greater is the need and grander the opportunity to live for one's country, and wage war against the powers of ignorance, indifference, disease and degeneracy. And this is the essence of the newer patriotism, which in no way removes or lessens the ancient duty of defending the land and honor of one's country, but at once idealizes and transcends that duty. If this be true, it follows that the man who is awake to his civic responsibility and who appreciates the honor of his American heritage will be in hearty sympathy with all agencies engaged in this distinctly modern line of endeavor. He will take part in, and aid to his utmost ability, those influences making for a cleaner and better America, because he realizes that this is not only his opportunity but his patriotic duty.

It appears therefore that the subject of the public health must not

LANDING STAGE FOR IMMIGRANT BARGES AT ELLIS ISLAND.

only interest, but must engage the loyal support of every good American. Yet the name itself means the same to no two people, and there exists an equally diverse opinion respecting the relative importance of the component elements of the public health, and the causal influences controlling it. However, it is unnecessary to bring up disputed points and impractical discussions when there are issues of the most vital concern involved in this question.

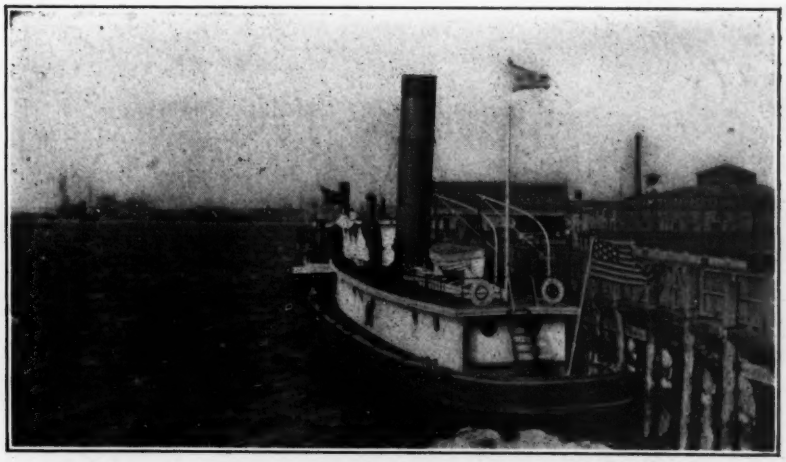
The public health, or the health of people en masse, in groups or communities, is more than an adding together of the conditions of health in which each person in the group finds himself. Just as the mob-sense, the group consciousness, or the dominant spirit of the mass, as one chooses to call it, differs from the individual personalities which compose it, so the public health differs from the individual health of each single person. The public health is intangible, though none the less real. It is not a static condition, which can be moved and delimited from without, but it is full of dynamic potentialities, and pregnant with unforeseen complications and denouements. The study of it leads into a bewildering array of intimately related subjects which at first glance seem to bear but a meager relation to it. A survey of its field must begin with an understanding of what is included in the term public health itself.

Public health may be considered to present itself in three phases, as physical, mental and social health. Each is influenced by many factors.

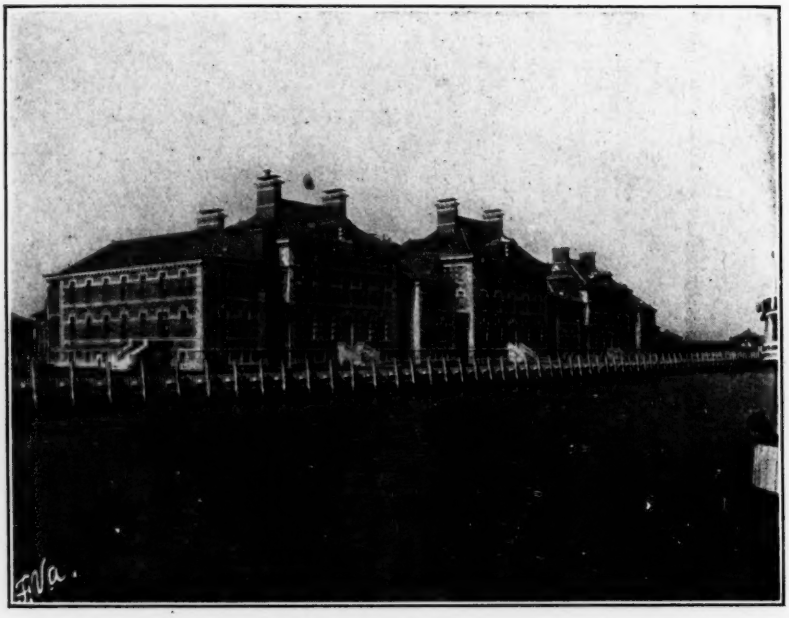
Certain features of the public health are most prominent from the social standpoint. The development of industrial life has brought many problems of most pertinent concern. Among them are industrial diseases, such as arsenic, lead and phosphorus poisoning, child labor, hours of labor, the employment of women in certain industries, sanitation of working quarters, and the responsibility of employers for the life and activities of employees outside of the workroom. The rapid growth of facilities for travel and the enormous number of travelers on railroads and steamships presents some unexpected problems in the sanitation of common carriers. Several instances are recorded of smallpox spreading in Pullman coaches. Mosquitoes, fleas, bedbugs and flies may easily carry an infection over long distances by aid of the railroad. A typhoid carrier can infect every water supply traversed by his train between Los Angeles and New York. The prevention of accidents in mines, and other industries, improved methods of controlling epidemics, and preventable diseases, and of saving the victims of common accidents like drowning, prevention of overcrowding in cities, proper housing of the poor; these are but a few of the numberless problems in the new science of public hygiene, from the standpoint of social public health.

The physical public health is concerned with communicable disease and its direct results, as in epidemics, while mental public health considers the prevalence, prevention and care of mental disorders, and the new science of mental hygiene.

One of the most important of the factors having to do with the public health is immigration. Not in the world's history has so vast an ethnic movement been recorded as that from Europe to America. The tribal migrations of ancient Europe are puny indeed compared to the great tide of a million and a quarter souls coming every year to the



BOARDING CUTTER "IMMIGRANT," ELLIS ISLAND.



IMMIGRANT HOSPITAL, ELLIS ISLAND.

United States. The tremendous bulk of this movement, together with the fact that it is drawn from such diverse and often mutually antagonistic races and nations, produces problems which not only are unique but whose proper solution is a matter of the gravest concern for the welfare and continuance of this country. The population of New York and of many sections elsewhere increases faster by immigration than by birth. These immigrants at best are only imperfectly and superficially sifted, and many enter to whom the privilege should be denied. The reason for this lies in the extreme difficulty of recognizing many physical and mental affections in their incipiency, in the shrewdness so often exhibited by the immigrant in concealing such defects, and in the loopholes that exist in the administration and interpretation of the law whereby many defectives who are detected are nevertheless admitted.

It goes without saying that the development of American ideas and standards in an immigrant foreign population will be inversely proportional to the density and homogeneity of that population in any section. Intermixture is the secret of assimilation. And assimilation is the test of desirable immigration. But not alone is the social and economic advance of the immigrant determined by his relations with Americans, for it is just as true that the immigrant will affect the standards and ideals of the American. This influence of the immigrant on the native population becomes operative in many ways, but none of these is so important and yet so complicated as the influence on the physical, mental and social health of the general population.

The medical inspection of immigrants is the first, most comprehensive and most effectual line of defense against the introduction of disease or taint from without. It is properly a feature of quarantine, and the two systems, immigrant inspection and national quarantine, might well be combined and condensed to their mutual advantage. Especially is this true since both systems have the same object, require a somewhat similar plant, and are both operated by the federal Public Health Service.

The influence of immigration on the public health thus constitutes perhaps the most serious feature of this vexing and much-discussed problem. Disease or defectiveness of mind or body in the immigrant must be considered from two standpoints. First is the immediate result on those with whom the immigrant comes in contact. Second is the effect on the descendants of the immigrant, and indirectly on the general public; in short, the eugenic aspect.

II. Direct Relations of Immigration to the Public Health

Certain diseases have been considered so dangerous to the individual or to the public as to be included in a list of conditions which are absolutely excluded by the immigration law. Among these are venereal and other dangerous or loathsome contagious diseases, including tuberculosis, trachoma, filariasis, and hookworm infection. Insanity, epilepsy and mental defectiveness are likewise excluded.

There is a growing recognition of the wide prevalence of venereal disease in this country, and of the insidious danger from it. But no

Medical Officers at Ellis Island.

ITALIAN, ALPINE TYPE.

matter how prevalent it may be, and regardless of the few cases that may be found among immigrants as compared with the huge number already existing, the exclusion of those few is a matter of deepest moment. It is extremely difficult to detect venereal disease in the routine examination of immigrants; even with the greatest possible vigilance, it is probable that many cases are not identified.

Acute diseases, including the ordinary contagious diseases, are stopped at the immigration station and kept in an isolation hospital until recovery has occurred. There is no serious danger from these because acute disease is easily recognized and ordinary quarantine precautions serve to prevent local epidemics.

Certain parasitic skin diseases such as favus and tinea tonsurans are excluded. These diseases are caused by a minute fungus which in itself is not dangerous to life or necessarily to health. But the lesions produced by these fungi are disfiguring and loathsome, and the disease is easily transmitted by contact, either directly from the patient or through the medium of domestic animals as cats and dogs, or of common hairbrushes, towels or linen. If the fungus invades the hair follicles and roots of the hairs, its eradication is a matter of the greatest difficulty and often impossible. It is this feature that makes favus and ringworm of the scalp practically incurable. The classification of loathsome and dangerous contagious diseases includes a large group, but the desirability of excluding immigrants possessing any of them rests on a few common principles. These diseases are all communicable and therefore may spread through an ever-widening circle. They are detrimental to the health and usually to the life and normal activity of the host. Occurring in the ordinary immigrant class, they decrease his productivity and

power of self-support, consequently laying an additional and undeserved burden on the rest of the community. Many of them result in the transmission of hereditary taint or predisposition or actual disease to posterity. And finally their admission into this country simply means a gratuitous and unnecessary assumption by this country of a burden belonging properly to the countries from which these persons come, and encourages those countries, as in the past, to unload their decrepit, worn-out and encumbering human stock on us.

Little is heard as to the bearing that immigration may have on the prevalence of tuberculosis. The status of tuberculosis is influenced by immigration in several ways. The disease in its pulmonary form is usually chronic and marked by a slow and insidious onset. Hence only a careful physical examination, often combined with a suggestive clinical history, will reveal the affection in its early stages, that is, in the first three to six months of its course. It must be borne in mind that the medical officer examining immigrants encounters the shrewdest evasion and concealment. Only too often the diseased immigrant is carefully coached by persons having knowledge of the methods of the medical examination. Altogether the task of the medical examiner is most difficult. It is estimated that 150,000 persons die each year in the United States from tuberculosis, and statistics put the death rate from tuberculosis at 10 per cent. of the total death rate. Yet in the fiscal year 1911, but 0.015 per cent. of the immigrants examined were certified for tuberculosis. This may be explained in no small measure by the fact that in the administration of the law excluding tuberculosis it is the rule to diagnose the pulmonary disease only when the tubercle

ITALIAN, SICILIAN TYPE.

bacilli have been found in the sputum. Moreover a microscopical preparation showing the stained bacilli must be submitted in substantiation of the diagnosis. The tubercle bacillus rarely appears in the sputum until the disease is well advanced and there has been a certain degree of destruction of lung tissue. To limit the diagnosis to such cases alone as show the bacillus allows numerous cases to pass free in which the clinical diagnosis is practically certain.

In this connection it is to be recalled that many deportation cases diagnosed as tuberculosis are referred to the medical officers for examination to determine if the disease existed or was due to causes existing

ITALIANS.

at the time of landing. In these cases it is customary for the certificate of tuberculosis to be based on a clinical diagnosis alone with no demonstration of bacilli in the sputum. This is the case even though the deportation of a tuberculous alien is a far more severe and radical procedure than to exclude such an alien at first.

It would be more effective to hold for hospital observation all cases presenting clinical evidence of pulmonary lesions, and to allow diagnosis in such cases as after careful and repeated examination showed a definite lesion, perhaps using the tuberculin reaction as an aid in selected cases. In other words, if the diagnosis of pulmonary tuberculosis could be made by a competent and careful physician, even though there were no bacilli in the sputum, the case should be certified as tuberculosis.

In the administration of the law excluding tuberculosis, only tuberculosis of the lungs, genito-urinary tract or gastro-intestinal tract is considered to be indicated. It would seem that an arbitrary limitation of the scope of the law to these three forms leaves out of account the serious nature of tuberculosis of the bones and glands at least. There is no doubt that the widespread popular interest and agitation against tuberculosis has overemphasized the importance of the tubercle bacillus, and the diagnosis and care of tuberculous patients. But equally or even more important is the prevention of the disease by sanitation, personal hygiene and increase of individual resistance to it. The bacilli, as Osler says, are ubiquitous, and practically every person is exposed at some time to infection. One of the very best reasons for placing tuberculous patients in sanitaria, and for scrupulous sanitary care of those who can not be so placed, is that each case, especially in the humbler walks of life, tends to become a constant focus of infection, spreading the germs broadcast. This is prevented by proper care. Linked with this consideration is the fact that the tuberculous patient tends to produce feeble offspring, predisposed to this and other diseases and defects. It is no small advantage to the community to have tuberculous cases in proper institutions where these dangers are averted. The advantages of removing tuberculous patients from contact with the general public in the ordinary activities of life are at least no greater than the advantages of preventing the entrance into the country of tuberculous aliens.

Another consideration which increases the danger of admitting immigrants who are subject to tuberculosis or other communicable diseases is based on the nature of the present-day immigration. More than four fifths of the immigrants entering the United States come from southern and southeastern Europe. As a type these peoples are ignorant of hygiene and sanitation. They live on a low plane. Overcrowding, disregard of privacy, cleanliness and authority, their gregariousness and tendency to congestion along racial lines in cities, are all important factors in the spread of disease among them and by them.

Among the diseases whose prevalence, manner of spread and results constitute a national health problem, trachoma must be reckoned. Trachoma is an inflammatory communicable disease of the eyelids, of unknown causation, having most serious sequelæ of deformity of the eyelids, impairment of vision and blindness. In Europe and Asia it is a terrible scourge. "Egyptian ophthalmia" has a long and famous history. The wide prevalence of trachoma in the United States and its importance in decreasing economic efficiency are only now beginning to be fully realized. It is stated that half of the 64,000 registered blind persons in the United States are needlessly blind and that the maintenance of one blind person for life by the community costs an average of $10,000. Sixty-seven per cent. of the blindness in the Ohio State Institution for

the Blind was found to be due to trachoma. In the Kentucky Institute for the Blind, a year ago, 45 per cent. of the blindness followed trachoma.

It is known that trachoma is a common disease of the American Indians, and its ravages are only equalled in seriousness by tuberculosis. In some sections of the southwest, from 65 per cent. to 95 per cent. of the Indians are trachomatous. Over 800 cases of the disease were operated upon and treated at the trachoma hospital of the Indian Service in Phœnix, Arizona, alone, according to the report of the Commissioner of Indian Affairs for 1911. A recent investigation covering 39,231 Indians in 25 states, one eighth of the total Indian population, showed 8,940 or 22.7 per cent. to have trachoma. At this rate there are 72,000 trachomatous Indians in the United States.

ITALIAN.

ITALIANS.

In 1911 Surgeon M. H. Foster, of the U. S. Public Health Service, made a survey of conditions of health and sanitation among the natives of Alaska. Of 1,364 Alaskan Indians examined over 7 per cent. suffered from trachoma, and nearly 3 per cent. were blind largely as a result of trachoma. The disease ranked with syphilis and tuberculosis as one of the most destructive to which the natives are subject. Recently Surgeon John McMullen, of the Public Health Service, has conducted a careful investigation as to the prevalence and seriousness of trachoma among the

mountaineers of Kentucky. Of about 4,000 persons examined, 500 or 12½ per cent. had trachoma. From 3 per cent. to 18 per cent. of the school children examined suffered from trachoma. At the semi-annual clinic held by Dr. J. A. Stucky at Hindman, Kentucky, in September, 1912, 374 patients were examined, of whom 113 had trachoma. Over 11 per cent. of the resident pupils of the settlement school at Hindman, and 16 per cent. of the day pupils suffered from trachoma. About one half of all those applying for relief to this clinic suffered from trachoma or its sequelæ.

The management of this newly recognized public health problem includes two features. First is the treatment and cure of existing cases of trachoma, and popular education in the hygienic and sanitary measures which will prevent its spread. Second, and equally important, is the prevention of the development of new cases. Probably the prevention of the introduction of new cases in immigrants is the most important single factor in the prevention of new cases and new foci of contagion. In 1911 a total of 2,504 cases of trachoma were certified in immigrants. Many of these were admitted, however, in spite of the medical certificate. At New York, for instance, where 1,167 cases were certified, 63 cases were landed. In 1912 of the 718 cases certified at New York, 64 were landed. If no inspection were made for trachoma, the victims of the disease would flock to the United States in hordes. We have a weighty and difficult problem in handling the trachoma already existent in this country. Every consideration demands its absolute exclusion in immigrants.

One other disease of national importance for the public health, and which has an intimate relation to immigration, is hookworm infection. The economic and social significance of this disease is well known. The Rockefeller Sanitary Commission for the Eradication of Hookworm Disease in its second annual report shows that a heavy infection exists in Arkansas, Virginia, Tennessee, Alabama, Mississippi, Louisiana, North and South Carolina and Georgia, and that a lighter infection exists in California, Nevada, Oklahoma, West Virginia, Kentucky, Texas and Florida. Maryland is probably also infected. The report states that hookworm disease belts the earth in a zone 66 degrees wide, extending from 36 degrees north to 30 south latitude. Practically no country within these boundaries is exempt.

It is a subtle disease with a chronic course, and it attacks the health and efficiency of its victims insidiously. It is beginning to do in the United States what it has already done in Egypt, China and India. It will be impossible to control the spread of hookworm in the United States as long as any considerable number of new cases are admitted in immigrants. The law rates it now as a dangerous contagious disease, subject to exclusion. The exclusion of Hindus at San Francisco on the certificate of uncinariasis practically stopped the immigration of

ORTHODOX GREEK CATHOLIC ARMENIAN CLERGYMAN.

East Indians through that port. The Rockefeller Commission estimated the rate of infection in India at from 60 to 80 per cent. of the population, and at San Francisco in 1911 65.6 per cent. of the Hindus were found infected. No immigrant should be admitted who is infected with hookworm. He should be treated until cured in an immigrant hospital or excluded at once.

HEBREW FROM GALICIA.

ARMENIAN.

These few diseases are selected merely as types to show the serious nature of the importation of actual diseases by immigrants. The list is far from exhausted by the instances we have discussed.

The phase of public health which may be termed mental health is susceptible to many influences. There is no doubt that successive ages of inbreeding, "racial incest," as Dr. H. M. Friedman calls it, results in a racial tendency toward, or characteristic of, mental instability and predisposition to a neurotic and psychopathic constitution. This is illustrated in the case of the Jews, where their highly developed emotional nature and predisposition to functional insanities may be laid to absence of fresh blood and to close racial inbreeding for many centuries. New blood is essential for racial or individual development.

If the tide of immigration brought to us only the good blood that this country needs, no restrictive examination would be required. But the mentally diseased and defective come in large numbers, and if the vigilance of the nation's sentries were relaxed ever so little, these numbers would swell to an overwhelming flood. Insanity and mental defectiveness are of grave concern from the standpoint of public health. The individual victim is predisposed to crime, is very likely to be not self-supporting, tends to become a complete public charge and, most serious of all, transmits a tainted heredity or actual mental disease to his descendants. Moreover, where physical disease or defect tends toward extinction, mental disease or defect is prolific and both insidious and far-reaching in its ramifications.

Dr. H. H. Goddard has recently made a complete hereditary study of the descendants of an Englishman of good ancestry who contracted an illegitimate union with a feeble-minded girl. A feeble-minded son married a normal woman and from this pair were descended 480 persons. Of these 480 persons, 36 were illegitimate, 24 were chronic alcoholics, 3 were epileptics, 33 were immoral, 8 kept houses of ill-fame and 3 were criminals; 143 were feeble-minded. In all that family only 46 were apparently normal. The legal union of the same ancestor with a normal woman resulted in 496 descendants, of whom but two showed abnormal mentality. Comment on this record is unnecesary. Its lesson should be kept in mind in considering the fact that the alien population of the United States is furnishing considerably more than its proportionate number of feebleminded and insane persons.

More accurate statistics are available for New York state than elsewhere in the country. But while New York is chiefly concerned with the problem of the alien insane and mentally defective, every other state has or will have the same problem in varying degree. It is authentically reported that about one per cent. of the school population of New York City, or about 7,000 children, are distinctly feeble-minded. In addition to these is an equal number of idiots and imbeciles, and the large class of morally defective children and border-line types. Census statistics show that the parents of 30 per cent. of the feeble-minded children in the country at large are aliens or naturalized citizens. In the first line of defence and prevention lies in a rigid primary exam-

CROATIAN.

ination of all applicants for entry. To put this mental examination of this ratio at least 3,000 of New York's 10,000 feeble-minded children are the progeny of the 9,000,000 immigrants of the last ten years.

Dr. T. W. Salmon writes that New York State is the destination of 26 per cent. of all immigrants coming to the United States, but that more than 80 per cent. of the immigrants found on arrival to be mentally defective or insane are headed for that state. He found more than 8,000 aliens in the New York State hospitals for the insane. The New York State Lunacy Commission reported to the legislature on February 14, 1912, that there were 33,311 committed insane cases in the state institutions. According to Dr. Salmon, more than 25 per cent. of these were aliens, who to a large extent had passed through Ellis Island. The capacity of the institutions was exceeded by 3,043.

Enough has been said to show the intimate relation obtaining between immigration and the prevalence and increase of insanity and mental defectiveness in the United States. It is recognized that these conditions are increasing to an alarming extent and the student of public health and preventive medicine must concern himself seriously with the control and eradication of the sources of this increase. So far as the immigration of the insane and mentally defective is concerned,

immigrants on a thoroughly adequate basis will cost money in large amount. But it is not only a good and economic investment, it is absolutely essential in order to conserve our national mental health and to ensure a normal mentality to coming generations.

Among the important agencies operating directly to promote mental public health is the present mental hygiene movement. This is a carefully organized effort of national scope, which is being directed and promoted by the National Committee for Mental Hygiene with headquarters in New York City. The field activities of this committee are under the direction of Dr. Thomas W. Salmon, of the U. S. Public Health Service. The object of the committee is to popularize the correct knowledge of the causes of mental impairment, to supply agencies for furnishing advice to persons threatened with, or actually suffering from mental breakdown, and to furnish preventive social service for such cases. Insanity is a disease and a large proportion of the cases are due to preventable causes. The National Committee is also making a medical survey of the country with reference to methods of caring for the 200,000 insane of the country. At present there is a lamentable lack of uniformity in the different states, in the facilities and methods employed in insane hospitals, and the standards of care are very low in many.

III. Importance of the Immigration Station for the Public Health

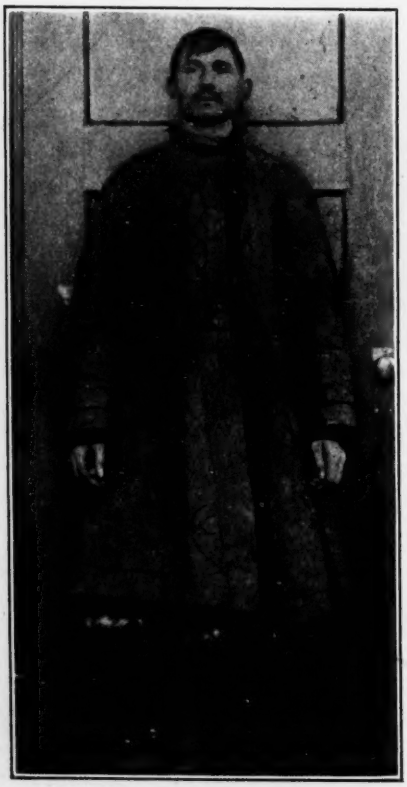
Any discussion of the relation of immigration to the public health must take cognizance not alone of the mental and physical effect of incoming immigrants on the present population, but must concern itself very particularly with the selection and enforcement of the best methods of excluding the unfit. The relative importance of the leading ports of entry in number of immigrants examined is shown in the following table:

	1909	1910	1911	1912
New York (Ellis Island).....	724,757	896,015	749,642	726,040
Boston.....	47,895	62,075	54,759	59,893
Baltimore.....	20,510	31,245	23,543	22,667
Philadelphia.....	15,083	39,671	46,857	47,742
Total for U. S.....	944,235	1,198,037	1,093,809	1,143,234

It is seen that Ellis Island, the immigration station for New York, is by far the largest port of entry. Hence it is the most representative place to study practical methods of immigrant examination. These methods have been described elsewhere in detail.[1] Certain features only need mention at this time.

[1] Alfred C. Reed, "The Medical Side of Immigration," The Popular Science Monthly, April, 1912; and "Going through Ellis Island," The Popular Science Monthly, January, 1913.

Only aliens of the steerage class are taken to Ellis Island. Aliens in the first and second cabin of arriving vessels are examined on board by medical officers of the Public Health Service who board the vessel as it leaves the New York Quarantine at the entrance to the bay. The present force of medical officers at the Ellis Island station is hard pushed to keep abreast of their continually increasing duties and responsibilities. No definite standard has yet been found for the mental and physical examination of immigrants. It is a new and very technical field in public health work.



A Little Russian in a Sheepskin Coat.

Magyar, showing Boots and Sheepskin Coat.

Experience and practise alone will show what is best. No absolute and ironbound rules can be laid down at present as to methods of administration and examination. These features make especially difficult the task of the medical examiners at Ellis Island. Being by far the largest port of entry, Ellis Island must of necessity have most to do with the determination of the best methods of examination, and of standards of examination which can be used elsewhere after being put to the test of actual trial here and modified in

the light of experience. In other words, Ellis Island is peculiarly adapted to be an experimental station in the mental and physical examination of immigrants. There is a tremendous need for such a station. The entire subject is new and, as has been pointed out, there is neither precedent nor experience to guide. It is a sophistical and beclouding argument that such work would be an injustice to the immigrant. In the strictest sense it would be an intensive study of the immigrant under the best possible surroundings to find out the best way of separating the sound and desirable alien from the unsound and undesirable.

Such work would find many definite problems in the diagnosis of disease. An instance in point is trachoma. Probably no better trachoma clinic exists in the country than at the Ellis Island hospital. So far the cause of the disease is unknown. Investigation of the etiology would naturally carry with it investigation of the best means of treatment and cure. Mention has been made of the importance of the hookworm and of its prevalence in the United States. There is a mighty host of intestinal parasites, several of which are fully as dangerous as the hookworm though not distributed so widely. An example of this is the fishworm, the *Bothriocephalus latus*. To exclude immigrants harboring these dangerous intestinal parasites or to cure them before they enter the country is very important.

Dr. M. W. Glover has noted that of 1,553 immigrants examined at San Francisco, 42.8 per cent. harbored the hookworm, not to mention numerous other parasites. He found that 29.4 per cent. of the 782 Chinese examined were infected, and notes the fact that the most marked evidences of infection were seen in Chinese boys. Dr. Glover makes the interesting suggestion that this apparently explains the puzzling observation of the discrepancy between the apparent age and the age claimed in many Chinese boys. In the fiscal year 1912, 941 cases were certified at Ellis Island for lack of physical development, in addition to 444 cases for poor muscular development and 36 for malnutrition. A large proportion of these cases were boys whose physical development did not correspond to the age claimed. Dr. Friedman notes such a disproportion as of common occurrence in the Mediterranean races and especially in the Greeks. It would be well worth while to institute an investigation to determine whether intestinal parasites or some other agency is responsible for these cases. The determination of this point would not only serve to clarify and give a more exact standard of diagnosis and certification of these aliens, but it would be of untold value in relieving similar conditions not only among our own people, but in the countries from which this class of immigrants comes.

The detection and diagnosis of mental conditions in immigrants is a matter of exceeding difficulty. This is in no small measure due to

the fact that no definite standards are available by which each immigrant may be judged as to his mental development and normality. Mental defectiveness or backwardness in the Pole or Russian expresses itself in a very different manner from the same conditions in a West Indian negro or in a Basque, or an Italian. Each is accustomed to a more or less limited and different range of experience. Each has a distinctive hereditary endowment and has grown up with a distinctive training, a peculiar environment and habit of thought and action. Experience and deduction agree that each must be examined by methods peculiarly suited to his own circumstances. Such methods can only be developed from the experience of trained men in the careful examination of many cases. Numerous cases are put through a detailed mental examination and released because no definite and recognizable sign of mental impairment could be obtained. Many have latent symptoms which are indefinite, but which if kept on record for a large number of cases would make possible a more exact standard of diagnosis. If a careful stenographic record were filed

RUSSIAN POLISH GIRL.

FINN.

of every such examination those cases which later after landing develop some definite psychosis or show positive mental impairment could have this original examination reconsidered in the light of later developments. From a large number of such cases it would be possible to formulate definite methods of original examination and to codify new symptom complexes for different races and classes. Tabulation of such symptom complexes and from them the establishment of definite standards of mental abnormality for the various races, would be in accord with the same principle as that followed in formulating the Binet-Simon measuring scale of intelligence, now used so widely in the diagnosis of mental backwardness, which was codified from a large number of mental examinations of French school children.

A few illustrations have been picked at random to show the enormous field of usefulness of Ellis Island as an experimental station of methods and standards for the physical and mental examination of immigrants. Of course there would be great gain incidentally to the cause of science and scientific medicine, and this gain would be shared directly by the public health conditions of the country. As a suggestion of the opportunity for obtaining data on related topics, it would be feasible to make an exhaustive study of muscular anthropology, or the racial and relative physical development of the living man. Abundant material is available for this at Ellis Island from every race and nation, and that, too, with no hardship and practically no delay to the immigrant.

Space forbids more than a suggestive sketching of what Ellis Island means for the best interests of the public health. Were a larger staff of medical officers available, it would permit the fuller utilization of observation wards in the immigrant hospital in the diagnosis of diseases of the lungs, kidneys, heart, blood, intestinal tract, and others where careful observation and laboratory examinations are essential.

An efficient immigration station requires a staff of specially trained interpreters. It is hard to overestimate the need for thoroughly trained competent medical interpreters. Of course the ideal arrangement would be for the examining physician to be able to address each immigrant in his own tongue, but this is manifestly impossible. It is hard enough to discover mental symptoms ofttimes when the examiner can converse fluently and sympathetically with the patient. Lacking a skilled, intelligent and honest interpreter, his task is well-nigh hopeless.

The medical examination is the only true examination of immigrants that is provided for under the law, or that is possible or even necessary. The real center and necessary essential of an immigration station is the medical division. If an immigrant is in a broad sense the possessor of mental and physical health his entry is desirable. Whether he shall stay, having once been admitted, could well be made

dependent on his meeting certain tests of education and financial self-support within a definite period. A healthy immigrant who passes such tests is the only alien who should be eligible for citizenship.

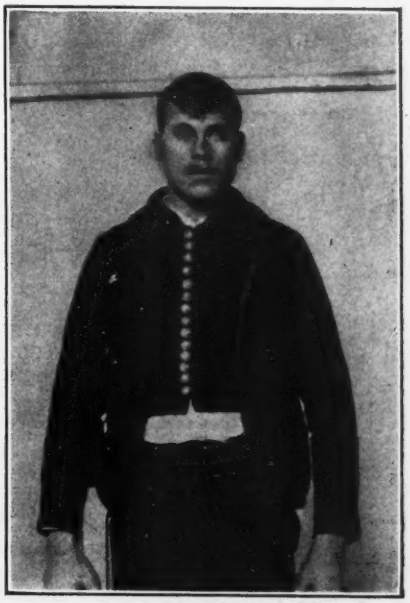
It is essential for the success of the medical examination that it be conducted in quarters especially arranged with reference to the needs of the examination. Well lighted and perfectly ventilated rooms are extremely necessary. For both the physical and mental examination a number of separate rooms are needed sufficiently large to prevent overcrowding. The immigrant is naturally frightened and nervous from

SLOVAK GIRLS.

his strange surroundings. Being detained for more complete medical examination increases his perturbation and anxiety. It is most important to allay his fears and remove the sense of strangeness, so far as possible, by avoiding overcrowding, by quiet and kind treatment, and by judicious arrangement of facilities and interpreters. These conditions are of no small importance in the conduct of the medical examination.

As has been stated, aliens in the first and second cabins of incoming vessels at New York are examined on board ship, and are not removed to Ellis Island unless such a course is required for medical attention or diagnosis, or unless the individual is held for a board of special inquiry to pass on his eligibility for admission. The conditions under which

the medical examination must be conducted on board ship are most disconcerting and difficult for the medical officer. The law regards all aliens alike, and the regulations governing the medical examination of aliens expressly make no distinction between those in the cabin and in the steerage. As a matter of fact, the chances of a defective immigrant escaping detection in the cabin are far greater than in the steerage. This depends on many factors of which space forbids more than mention. The aliens of the first cabin are frequently discharged without examination by the medical officer. In the confusion and excitement on board an arriving liner not infrequently defective aliens as well as others are passed with no medical examination.



SLOVAK.

ROUMANIAN.

It is not true that immigrants come only in the steerage. On many lines the second and even the first cabin brings a class of alien passengers distinctly inferior to the steerage of such lines as the Scandinavian and Scotch. In his report for 1911 of the medical examination of aliens at Boston, Dr. M. V. Safford says:

> Six per cent. of the steerage passengers arriving at Boston were United States citizens, and over three fourths of the second cabin passengers were aliens. About 25 per cent. of the aliens arriving at Boston come as cabin passengers. It appears that over 7 per cent. of the alien second cabin passengers were certified as

seriously defective or diseased, while only 4 per cent. of the alien steerage passengers were so certified.

These figures may be taken as representative, although unfortunately similar figures are not available for Ellis Island. No more is needed to show that relatively the cabin examination is at least as important if not in fact more important than the steerage examination.

Dr. Safford very aptly points out that "long-established custom dictates that the medical inspection of cabin passengers must be made somehow on shipboard whenever they may arrive, day or night, and that they can not be removed to a suitable place ashore for the purpose." This custom is pernicious when made ironclad. In some cases the examination can be conducted satisfactorily on shipboard. An exception should be made by the immigration inspectors in favor of these cases only, and the rule should be that all aliens should be examined in a satisfactory station on shore. The law designates the regular immigration station as the place of examination of all aliens, unless the commissioner of immigration expressly appoints some other.

GERMAN SWISS.

GERMAN POLAK.

IV. Deportation of Unsound Landed Aliens

But the exclusion of unsound aliens includes more than a competent medical examination at entrance. Many cases of incipient disease both physical and mental are unrecognizable at the time of entry except by detailed and refined methods of diagnosis which are absolutely impracticable in the routine examination of large numbers of immigrants. Also the cleverness and cunning of defective aliens may easily conceal from the examiner some unobtrusive though important sign of defect or disease. Such cases are very apt to come to light sooner or later after landing, in hospitals or other public institutions. As Dr. Friedman says:

> The detection of mental disease among aliens offers the same difficulties in an infinitely larger degree. The goal in this work is to be able to detect from the panorama of people those who have remote or only latently present mental abnormalities. There are no signs by which an examiner can say in any given instance that an individual will develop a mental disease.

In addition it is impossible for an examination at the time of arrival to indicate how successfully a given immigrant will react to the stress and strain of American life, and whether some latent tendency or weakness may not be developed under the new conditions. In short the medical examination at entrance must be supplemented by examination at a period later in case some latent disease manifests itself.

The law takes cognizance of these circumstances by providing for the deportation of aliens who, within three years of landing, become public charges or develop any of the excludable diseases from causes existing prior to landing. An example of the need of this law and of its operation may be seen in the case of pulmonary tuberculosis, due to causes present when the alien landed but not appearing in definitely recognizable form until months later.

Even more striking is the value of this law in insanity, epilepsy and mental defectiveness. These conditions are excludable but often escape detection on the primary examination. Within the three-year limit, however, a large number of such cases develop. Many forms of insanity and epilepsy are known to be due to hereditary constitutional defect and psychopathic tendencies. Hence if one of these becomes apparent within three years after landing, the diagnosis shows that the causes must have existed prior to landing. Of course feeble-mindedness, idiocy and imbecility are congenital and one of these conditions found within three years is evidently under the law.

Feeblemindedness differs from imbecility only in degree, and in its lesser forms in turn shades off into simple backwardness of mental development. A case may have been given the benefit of the doubt on the primary examination, when later conditions indicate it to be feeble-minded. An infant or young child may show feeble-mindedness within

ALGERIAN ARABS AT ELLIS ISLAND.

three years which was not apparent at entrance. Or, especially in the cabin examination on board ship, a feeble-minded person may entirely escape detection. These instances illustrate both the need for the law and its effectiveness. It is the second line of defence against unsound aliens, augmenting and reenforcing the first line of defence at the immigration station.

Unfortunately the effect of this deportation law is nullified in many cases by decisions of the Secretary of Commerce and Labor.[1] Certain of these decisions should have the widest publicity and will be a surprise to many persons.

Decision No. 120 of the solicitor of the Department of Commerce and Labor was published on February 8, 1912, for the guidance of immigration officials and others concerned. Within the legal three-year limit, Yittel Goldfarb, a sixteen-year-old Russian Jewess, was certified to be suffering from manic-depressive insanity by a member of the New York State Board of Alienists, an officer of the Public Health Service, and officials of the Manhattan State Hospital for the Insane where she was confined. The unanimous medical opinion was that, while the insanity had developed after the girl had landed, it resulted from causes in existence before landing. These causes were stated to be constitutional psychopathic tendencies and mental instability. It is held by competent alienists that manic-depressive insanity is always based on hereditary tendencies and mental instability. The apparent or immediately pre-

[1] The newly established Department of Labor, with Secretary William B. Wilson at its head, now includes the Bureau of Immigration, and it is probable that this policy will not continue.

ceding cause acts only as an exciting agent in bringing to fruition what was previously latent. It is to be noted that this decision does not question the diagnosis, but it states the opinion of the lawyer who framed it that the existing condition of manic-depressive insanity did *not* depend on causes prior to landing. In the light of this decision a warrant was refused for the arrest and deportation of the alien in question. As a consequence deportation is impossible in a class of cases which formerly supplied about 350 deportations annually.

On February 25, 1912, Mariase Lipschutz, aged 25, arrived from Russia on the steamer *Campanello*. On February 28 she was certified by the medical officers at Ellis Island as being feeble-minded. On March 28 she was ordered landed by the Secretary of Commerce and Labor, for the avowed object of visiting a sick relative. Her visit still continues.

On June 25, 1912, Rewke Palayes, aged 11 years, arrived from Russia on the steamer *Rotterdam*. A special certificate of imbecility was issued by the medical officers at Ellis Island, this carrying with it a fine of $100 for the steamship which brought her. On July 13 she was ordered landed by the Secretary of Commerce and Labor. The immigration law declares that minor children of naturalized citizens, if these children are dwelling in the United States, shall be considered as citizens. The father of this girl was a naturalized citizen. The Secretary contended that "constructively" she became a resident when she had left her foreign domicile, even though she had not even been admitted into the United States. She was ordered landed.

An exactly parallel case was decided in an opposite manner in an

FRENCH CANADIAN FAMILY ENTERING FROM MONTREAL.

opinion of the Supreme Court handed down by Justice Day on January 7, 1907, in the case of Charles Zartirian *vs.* George B. Billings, Commissioner of Immigration at Boston. Here the Supreme Court decided that a naturalized citizen's child was not a citizen and was properly excluded because it was suffering from trachoma, a disease subject to mandatory exclusion. The opinion stated that

> The petitioner's child, having been born and remained abroad, clearly does not come under the statute. She was debarred from entering the United States by the action of the authorized officials, and, never having legally landed, of course could not have dwelt in the United States. Congress has not said that an alien child who has never dwelt in the United States coming to join a naturalized parent, may land, when afflicted with a dangerous contagious disease.

The Zartirian case and the Palayes case are just parallel. The Supreme Court decided that the Zartirian child should be excluded. The Secretary of Commerce and Labor decided that the Palayes child should be admitted.

Space is insufficient to dwell further on the loopholes in the deportation of these cases, or to discuss possible improvements in the deportation law. A factor which is far from inconsiderable is that many cases legally subject to deportation, within three years of landing, are not reported to the proper officials. It is earnestly to be hoped that a thoroughly efficient primary medical examination of arriving immigrants may be augmented and reenforced by a strict administration of the deportation laws.

Recapitulation

The subject of public health is of most pertinent and vital interest. Immigration is an influential factor in the physical, mental and social health of the United States. From the standpoint of the public health, it is absolutely essential to exclude unsound immigrants, and the second line of defence against them is a rigid administration of the deportation law. How best to exclude unsound immigrants is a new and pressing problem of the public health.

AN IRISH CHANNEL RAILWAY

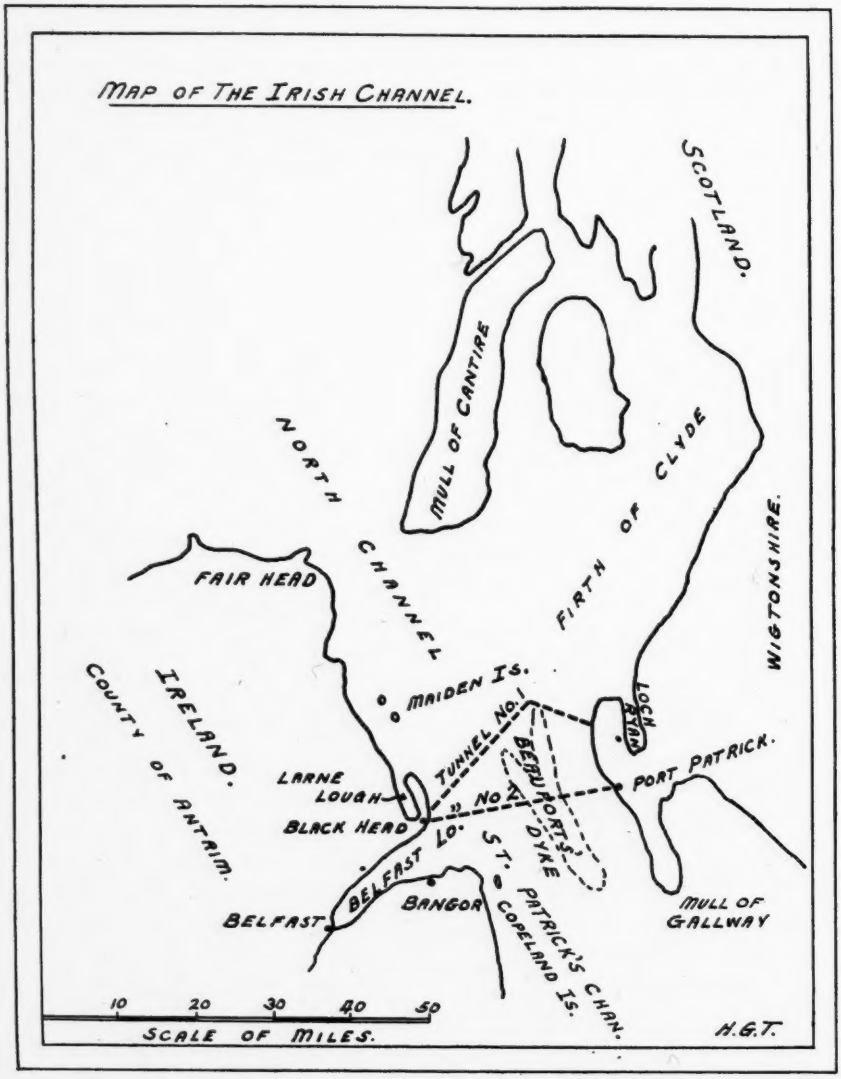
By HENRY GRATTAN TYRRELL, C.E.
CONSULTING ENGINEER, CHICAGO

IRELAND does not seem to have ever enjoyed so great a degree of favor and prosperity as other parts of Great Britain, notwithstanding the continuous efforts which, for centuries, have been spent in its behalf. This may be due to some extent to its isolated position and the presence of the Irish Channel which unfortunately separates it from England and Scotland. Money and lives have been freely given to secure political union and better conditions, and enormous energy has been expended to improve the social and commercial standing of Ireland and its inhabitants.

In the light of modern industrial development, the question may reasonably be asked: "Are there not other and more modern and rational ways of bettering Ireland, which, for centuries, has given and is still giving to the world many of its greatest leaders?" Viewing the problem of social and commercial betterment from the standpoint of the constructor or industrial engineer, it would seem that the policies which have been so generally successful in building up and uniting parts of other countries, should also meet with success here. Since the days of the Roman Republic, the building of roads and the linking together of separated states and provinces has proved to be most efficacious, and almost essential to commercial greatness. Realizing the need of road development, the Romans introduced their great policy of highway extension as their best and surest means of developing and uniting their great dominion. It is almost needless to say that the same policy of building roads and other channels for commerce has, for a century or more, been the most successful of all the means adopted for opening up new territory in America, Africa, Australia, China and other countries. The great railway systems of Canada and the United States, the canals at Suez and Panama and the systems of roads and inland canals in Great Britain itself, are evidences of profitable commercial extension due to the opening up of highways of transportation.

Considering the problem from the viewpoint of the engineer and builder, rather than from that of the politician or statesman, it would seem that a positive railway connection between Ireland and England should be of great advantage. The western island, with its population of five million people, still remains separated from England by a sea

which requires several hours to cross, and though easily navigated, trade is greatly impeded by this water barrier. The advantages of a railway connection across the Irish Channel are many and easily understood. Such a railway would shorten the time for crossing the



Atlantic from America by a day or more, and develop terminal ports on the Irish coast, thereby enormously increasing the local commerce, and offering larger chances for employment and extended opportunities to its people. The Irish railways would, in fact, become the through routes from America to India and the far east, instead of being subordinated, as they now are, for local business from Liverpool and Glas-

gow. Railway traffic in Ireland would be further increased if a similar line crossed the channel from England to France, making through rail connection from Great Britain to the Continent. Under present conditions, ocean traffic from America to Ireland frequently goes first to Liverpool and thence back to Dublin or Belfast, with a corresponding delay. For local commerce between Ireland and the east, the time of transportation would be shortened by only two or three hours, and yet, for improving railway facilities from England to the north, the great Forth Bridge was built at a cost of $13,000,000.

One of the difficulties in connecting the railway systems of the Islands is the difference in their gauge, which is 4 feet 8½ inches, or standard width in England, and 5 feet 3 inches in Ireland. This difficulty could be overcome in some one of several ways, such as (1) transferring cargoes at the border, (2) changing all tracks to standard gauge, or (3) laying a third rail on both systems. Any of these methods would be costly, but a change would necessarily follow the construction of a channel road.

In selecting a location for the channel road, it will be found that the shortest distance across is from Tor Point in Antrim to the Mull of Cantyre, the length of which is fourteen miles, but this course would involve other difficult water crossings in Scotland, and the line would lead far to the northwest, making the course impracticable. A better location further south is that from Whitehead on the Irish coast, northeast of Belfast, to Port Patrick, the distance being twenty-three miles. An unfortunate feature of the latter course is the presence of a central valley or depression known as Beaufort's Dyke, the bottom of which is two or three hundred feet lower than other parts of the sea, which has a normal depth of 400 to 500 feet, making a total depth of 600 to 800 feet in this depression. Geologists declare that at one time there was no dividing sea, but only a central valley now known as Beaufort's Dyke, and during the Pleistocene period the land was submerged, forming the present Irish Sea and Channel.

There are at least four possible methods of establishing a railway across the channel: (1) a continuous embankment or causeway, (2) a submarine tunnel, (3) a submerged floating tube or viaduct and (4) a bridge.

A continuous embankment across the channel would cost at least $100,000,000, and possibly more, and it would interfere with shipping. It could be used for a double-track line of railway and for developing electric power from the strong northern current, which would be fifty times more productive of power than the whole Falls of Niagara. Such obstruction of the natural currents would, however, lower the water in the harbors of Glasgow, Liverpool, Belfast and Dublin, an objection of rather serious moment. Since the proposed causeway

over to Scotland would lead in a northwesterly direction, the present water route to England and London would be shorter and quicker, and it is doubtful if the causeway would be practicable.

Investigations show that the best way of establishing a channel railway to Ireland is either by means of a submarine tunnel or a floating tube, the cost in both cases being much less than a bridge or causeway. The deep water of Beaufort's Dyke could be avoided by selecting a location from Laggan Head to Maiden Island and thence over to Antrim, or by bending the tunnel to the north around the end of this depression, and thereby increasing the tunnel length under the water to twenty-five miles, with a total length of thirty-five miles, including the approaches. A two-track bore, 150 feet below sea bottom, under water 500 feet deep, would probably cost $50,000,000 to $60,000,000 and the possibility of building it would depend wholly upon finding rock strata absolutely water-tight and impervious. Tunneling with compressed air to exclude water is possible only at depths not exceeding about 150 feet below the surface of the water, for then the atmospheric pressure reaches 75 pounds per square inch, and pressures and depths not exceeding half these amounts are usually enough for effective work. It is evident, therefore, that water could not be excluded by means of compressed air at the depth which would be necessary beneath the Irish Channel, and, as previously stated, the possibility of carrying on such work would depend entirely on finding impervious strata, the presence of which could not be definitely determined until the bore was made. The overhead thickness of rock in the Mersey tunnel is 30 feet, and in the Severn tunnel it is 40 feet.

It appears, therefore, that a tunnel would cost from $35,000,000 to $50,000,000, according to its location and other conditions, and would require from ten to twelve years for its construction.

Another method of crossing the channel is by means of floating tubes, lying either on the surface of the water or anchored far enough beneath the surface to allow ships to pass over out. While no structure of this kind has been built, somewhat similar submerged floating piers have occasionally been used, such as those under two swing bridges at Dublin, and the later one at Norwich, England. Very interesting designs for floating piers also appeared in a recent competition for a new bridge over the Hooghly River at Calcutta. The type is probably the most practical of all methods for crossing a navigable channel of so great a depth.

If the tubes were to float upon the surface, openings must be left for water travel, and this can be done by depressing occasional sections, four to five miles apart, leaving openings of 1,000 feet, the presence of the openings being indicated by signals. The depressed sections would connect with those on the surface by means of suitable grades. As the

heaviest ships now afloat have a draft of about 36 feet, a depth of 40 to 45 feet in anticipation of increased draft, should be provided, as is wisely made in the Panama Canal. The roadway level would then lie about 60 feet below the surface, instead of down beneath Beaufort's Dyke, and the approaches would be proportionately shorter. In a submerged position they would not be subject to pressure from wind and wave, but would lie in comparatively quiet water. The chief objection to these tubes is their deterioration from rust, and the difficulty or impossibility of repairing them under water. When the metal is corroded through, the concrete or other lining would be the only remaining material for resisting external pressures. Since the tubes would be supported along their whole length, they would need a comparatively small section for strength, and if lying on the surface, the tubes would be proportioned like ships, to receive varying support, and to bridge the waves from one crest to another. The weight of the submerged tubes should be such as to nearly equal the weight of water displaced. If slightly less than the weight of water, there would be an upward pull on the anchors when empty, and a corresponding downward thrust under moving load, to be resisted by surface floats. If so arranged that the upward and downward pressures are equal, the forces under normal conditions would be a minimum, and the cross section of the tubes might be nearly or quite uniform throughout. The tubes would be made in convenient lengths of 200 to 400 feet, with their ends temporarily closed, and floated out into position and sunk to their desired depth, where they would be connected. The temporary dams should be 3 to 4 feet back from the ends, leaving space for the divers while bolting the sections together. A submerged viaduct of this kind across the Irish Channel could probably be built for $25,000,000 to $30,000,000, and the type is the most promising of all to put into execution.

Whether or not a channel railway would be profitable as a financial investment is uncertain, but it would accomplish a far greater purpose than merely earning dividends, for it would increase commercial activity in Ireland, and with government security for interest on the investment, it might in the end be one of the easiest means of bettering conditions there.

A high-level bridge over water of such great depth would necessarily be on floating piers, and its cost would be from $150,000,000 to $200,000,000—so great indeed as to be prohibitive.

The construction of a channel railway to Ireland, and a ship canal from Galway Bay to Dublin, the cost of which would be about $40,000,000, are of the utmost importance to the prosperity of the island and its people, for ocean ports would then be established on the west coast of Ireland, and this long neglected part of Great Britain would participate to a greater extent in the general welfare.

SCIENTIFIC STANDARDS FOR THE GOVERNMENTAL REGULATION OF FOODS

By JOHN R. MURLIN, A.M., Ph.D.

ASSISTANT PROFESSOR OF PHYSIOLOGY, CORNELL UNIVERSITY MEDICAL COLLEGE, NEW YORK CITY

THUS far in our attempts to regulate by law the purity of foods admitted to interstate commerce, practically no attention has been paid to the real physiological economy of foods. Questions of purity, of what constitutes an adulterant, "What is ice cream?" etc., have been much before the public and much before the courts. The bone of contention in most cases has been not how much food value does a given product contain, but is it properly labeled or is it adulterated?

From the strictly legal point of view anything is an adulterant which belies the label; but from the physiological point of view nothing is an adulterant unless it really impairs the food value. Jams made with commercial glucose instead of cane sugar might very properly be excluded from commerce under the law as it stands, unless the label states clearly the fact that glucose is contained; but such jams would have exactly as much food value as if made of ordinary sugar, for glucose yields as much energy to the body as does cane or beet sugar. Similarly, nobody likes to be defrauded even in a technical sense and get oleomargarine under the label of butter, but how does the matter stand if oleo proves to be just as nutritious as butter? Is it not time there were an adequate standard for judging of food values? Should not the food manufacturers—those who put up foods in packages and sell them under protected trade marks—be required to correctly express on the label the real physiological value of their products? If the purchaser has a choice of oleo plainly labeled at 25 cents a pound or of butter properly so designated at 40 cents a pound, what determines his choice? First of all, probably, the taste. But if it were practicable to show also the relative food value of the two parcels, would not this factor enter into his decision, and is not the purchaser entitled to this information? Similarly with other kinds of food. Take the cereal breakfast foods. Their number is legion. How is the purchaser to make an intelligent selection? At present the only way is first to buy and try the taste, the "lasting qualities," etc. But if it were possible to learn from the label its fuel value the housekeeper would be able to select from the staple articles either the most pleasing or the most nourishing foods.

According to the best scientific information to-day foods serve two

main purposes in the animal economy: (1) They supply building and repair materials, and (2) they furnish energy for all the physiological activities. Let us consider the latter purpose first. Physiologists have demonstrated by numerous experiments that all the energies manifested in the body finally leave the body as heat which can be measured by an instrument known as the calorimeter. The heat unit employed in these calculations is known as a calorie, which is the amount of heat necessary to raise one kilogram of water 1° Centigrade. The quantity of heat measured agrees exactly with the quantity which may be calculated from the known amount of oxidation of foodstuffs which has taken place in the body. When muscular work is done in a calorimeter and the work is all made to take the form of heat, the increased heat production is again what it should be as judged by the increased oxidation. Similarly, the energy value of foods is determined either by analysis and computation or by burning it in oxygen. Given then foods capable of producing a certain quantity of heat, it is a fairly easy task to compute the amount of each which would be necessary to furnish the energy requirements of the body under any given set of conditions.

An engineer who wishes to supply a certain amount of power must know the heat value of certain kinds of fuel and the waste from each. From these he reckons the net cost of his power. Any one who cares to do so can make the same sort of a computation for his body. If the engineer pays $7 for a ton of coal, he sees to it that he gets $7 worth of heat. Why is it not just as reasonable when a person pays a certain price for food to expect a certain amount of food value? To demand the worth of one's money in heat units when the fuel in the house is under consideration is a plain proposition, and when housewives generally understand food values it will be a plain proposition in respect to fuel for the body. A properly educated public opinion will demand from manufacturers such information in regard to the food on which its energies depend.

Let us see if this is not a practical suggestion, and whether, after all, it may not prove a simple solution to a supposedly difficult problem. If our foods were all simple substances like sugar or olive oil, and if the energy content of the food were the only one of which we need take any account, the problem would be just as easy as calculating the yield of energy in horse-power from a ton of coal. It is because our foods are mixtures of various foodstuffs, each having a different fuel value and a different functional value, that the matter requires some study.

The simplest method yet devised for keeping account of the energy supply in one's diet is that devised by Professor Irving Fisher, of Yale University. The idea underlying this method is to do away with intricate calculation by familiarizing one's self with the amount of each

article of food, as purchased or as served on the table, which yields 100 calories of energy. This he has called the "standard portion."[1]

Often it happens that the quantity required to make a standard portion is a very convenient amount to serve on a plate. One large egg, weighing 2 ounces, is almost exactly a standard portion. An ordinary serving of butter (½ ounce), a teaspoonful of olive oil, one large orange, one large banana, one medium thick slice of white bread—each contains very nearly 100 calories of energy. By an easy computation one can readily learn the exact weight of any kind of food whose composition is known, which will yield 100 calories. It would help greatly if some enterprising manufacturer were to place on the market standardized measures made in metal for a standard portion of sugar, milk, rice, butter, oatmeal, flour, dried beans and any other food which does not vary much in composition. The only difficulty with this method is that certain food products as purchased in the market differ considerably in composition. It would therefore be much simpler for the consumer if the food manufacturer were required to guarantee not only the purity of his product in the ordinary sense, but to guarantee also a certain energy content. If, for example, a certain brand of oatmeal bore on its label the statement, "This package is guaranteed to contain 2,000 calories of heat energy," this information would be worth many times as much to the purchaser as the statement, "This food is guaranteed to comply with the food and drugs act," etc. For he would then have some basis upon which to judge the actual economy of his purchase. Some other product likewise "guaranteed to contain 2,000 calories" might cost him only one half as much.

Such a guaranty would entail no great hardship on the part of the manufacturer, because it would involve the employment only of a competent chemist to make an occasional analysis, or a determination by combustion of the heat value. The law of many states already requires that milk admitted to the markets must not fall below a certain percentage of fat (cream). If the label on top of the bottle were required to state, "This bottle contains 650 calories of food energy," the legal requirement would mean something to the purchaser, for it would enable him to tell whether milk is or is not a cheap food as compared with, say, oatmeal or eggs.

A person *must* have a certain minimum of energy value in his food every day. There is no law of nature more inexorable than this. Certain faddists like Horace Fletcher have averred that they live on much less energy than does the average man, and yet when Mr. Fletcher was

[1] By writing to the Superintendent of Documents at Washington the careful student of the problem can have a list of publications on foods. Bulletin No. 28 of the Department of Agriculture, published in 1906, price five cents, entitled "Composition of American Foods," by Atwater and Bryant, contains nearly all the information required regarding the fuel value of the common articles of food.

put into a calorimeter at Middletown, Conn., it was found that he lost from his body nearly if not quite as much heat as the average man of his age and stature. To keep himself in an equilibrium of substance it would therefore be absolutely necessary for him to take at least this quantity of potential energy in the form of food.

A few months ago a certain New York daily widely advertised the light diet by sending on foot to Chicago a woman who claimed to be living on nuts, salads, orange juice and the like. When she arrived at Chicago it was found that she weighed some 12 pounds less than when she left New York and yet the feat was declared to be a "triumph" of the woman's regimen of light foods. As a matter of fact she had not lived on these light foods alone, but had lived largely at the expense of her own body fat. In other words, she had a large part of her fuel for the trip already in storage. If the twelve pounds which she lost were all fat, as it probably was, this alone furnished a large part of the energy of walking for the forty days (I believe it was); for every ounce of fat burned from her own tissues gave about 250 calories of energy and in 12 pounds there would be 48,000 calories or about 1,200 calories a day. If she had added 4.8 ounces of fat or a little more than twice as much starch or sugar every day to her bill of fare she would have arrived in Chicago weighing as much as when she left New York.

Cold weather raises the requirement for energy, for the body loses more heat to its environment, unless this heat is kept in by warm rooms or warm clothing. The law of energy requirement applies most severely therefore to those who can least afford to buy a large supply of food. How important it is that their money should be made to go as far as possible! The pure-food law at present operates to protect those who use more highly flavored foods and drinks rather than the poor. If every kind of food purveyed in packages, tins, bottles, etc., bore a label stating its energy value the poor and all would soon learn how to make the money go farthest.

When it comes to the actual task of calculating the body's requirements it is customary to begin with minimal conditions. A person, uses the least energy when he is resting and fasting and is kept warm—lying in bed for example. When he moves about—that is, does muscular work, when he digests a meal, or when he is exposed to cold, he uses more energy. The average utilization in twenty-four hours under minimal conditions is about fourteen calories per pound of actual body weight, or for a man of average weight (154 lbs.) 2,150 calories. We should not miss it far if we should say that a person sitting up would use one calorie per pound more (2,300). And if he digests three meals a day he uses an additional calorie per pound (2,450). If, now, he does light muscular work, like typewriting, he uses about 25 calories per hour for this work, or in eight hours 200 calories, making the total for a man of average weight 2,650 calories.

If the person's work requires him to walk about all day, instead of sitting still and using his arms, he, of course, does the work of carrying his body, to say nothing of the other things he may carry, and the allowance must be three or four times as great as in the case of typewriting. A soldier on the march, walking less than three miles an hour, has been found to use 160 calories per hour for the muscular work alone. Most occupations which involve walking are less exacting because there are frequent rest periods. So, if we allow 75 calories per hour, it will probably supply the extra energy requirement over that of complete muscular rest, for, say, a fairly active salesman. This total intake in three meals, if he is of average weight, would be some 400 calories (four standard portions) more than that of the office worker. Two sample diets constructed so as to contain the twenty-four-hour requirements for the office worker and the salesman, respectively, are given below:

TABLE I

FULL DAILY SUPPLY OF ENERGY FOR A SALESMAN OF AV. WEIGHT (154 lbs.)

Breakfast	No. of Portions	No. of Protein Calories
1 small orange	½	3
2 shredded wheat biscuits	2	26
Vienna roll and butter	2	12
1 egg, soft, fried or poached	1	32
2 thin slices bacon	1	6
Coffee, cream and sugar	½	2.5
Total	700 cal.	81.5
Luncheon		
Ordinary serving beefstew	2	24
Tomato and beet salad with dressing	1½	15
2 slices bread and butter	3	28
Apple tapioca pudding, large serving	2	2
Cocoa, cream and sugar	1	4
Total	950 cal.	73
Dinner		
Cream of celery soup	½	8
Ordinary serving roast lamb	3	120
2 baked potatoes	2	22
Side dish green peas	2	50

FULL DAILY SUPPLY OF ENERGY FOR AN OFFICE WORKER OF AVERAGE WEIGHT

Breakfast	No. of Portions	No. of Protein Calories
1 small orange	½	3
Large serving of oatmeal	1	18
Cream and sugar	1	2.5
2 slices dry toast	2	28
Ordinary serving butter	1	0.5
2 eggs, soft boiled	2	64
Coffee, cream and sugar	½	2.5
Total	800 cal.	118.5
Luncheon		
2 small tomato and lettuce sandwiches	2	28
1 large glass whole milk	2	38
1 ordinary piece apple pie	3	15
Total	700 cal.	81
Dinner		
Plate of bouillon	0	0
Small serving rib roast	2	50
2 small potatoes with butter	3	20
Ordinary serving rice pud-		

Salad with mayonnaise ...	1	0	ding with cream	2½	20
2 slices bread and butter .	3	28	Bread and butter	2	18
Milk custard	1	26	Demitasse black coffee ...	0	0
Small piece sponge cake ..	1	7	Total	1,150 cal.	124
Total	1,350 cal.	261	Grand total	2,650 cal.	
Grand total .....3,000 cal.			with about 12 per cent. protein.		
with 13 per cent. protein.					

It will be clear from what has been said above that the requirements of the body for muscular labor in winter will depend on whether a person works indoors or out. Lumbermen who work in the north woods in winter probably require more food than any other class of laborers. At the opposite extreme, so far as external conditions are concerned, stand the men who work in factories, beside furnaces, etc. Their muscular work may be just as heavy as that of the lumberman, but their bodies are kept warm by artificial heat. The problem for them, as for ordinary laborers outdoors in hot weather, is rather that of removing the extra heat of muscular work.

Between these two extremes, naturally, are people who are subjected to conditions of all degrees of severity. It is impossible to prescribe a day's dietary which will fit all of them. We select a teamster and a foundryman of average weight. The former we suppose not only does the heavy muscular work of lifting boxes and cases, but is exposed to cold winds and rains. The latter does heavy work but is kept warm at his task.

A person who follows his natural craving will find himself eating more meat, especially more fat meat, in winter than in summer. This is not merely because fat meat contains more energy for the same weight than starchy foods, but because foods rich in protein and fat stimulate the processes of combustion by which heat is produced. For example, a day's diet consisting of nothing but lean meat would increase the heat production by about 30 per cent. The same diet consisting exclusively of starchy foods would increase it only about 5 per cent. This is the reason why laborers in the open crave meats more than do those who work indoors.

TABLE II

SAMPLE DIETS FOR A TEAMSTER AND A FOUNDRY WORKER

FULL DAILY SUPPLY OF ENERGY FOR A TEAMSTER OF AVERAGE WEIGHT			FULL DAILY SUPPLY OF ENERGY FOR A FOUNDRY WORKER OF AV. WEIGHT		
Breakfast			*Breakfast*		
	No. of Portions	No. of Protein Calories		No. of Portions	No. of Protein
3 wheat cakes	3	45	Large serving oatmeal ...	1	18
with maple syrup	1	0	Cream and sugar	1	25

If the person's work requires him to walk about all day, instead of sitting still and using his arms, he, of course, does the work of carrying his body, to say nothing of the other things he may carry, and the allowance must be three or four times as great as in the case of typewriting. A soldier on the march, walking less than three miles an hour, has been found to use 160 calories per hour for the muscular work alone. Most occupations which involve walking are less exacting because there are frequent rest periods. So, if we allow 75 calories per hour, it will probably supply the extra energy requirement over that of complete muscular rest, for, say, a fairly active salesman. This total intake in three meals, if he is of average weight, would be some 400 calories (four standard portions) more than that of the office worker. Two sample diets constructed so as to contain the twenty-four-hour requirements for the office worker and the salesman, respectively, are given below:

TABLE I

FULL DAILY SUPPLY OF ENERGY FOR A SALESMAN OF AV. WEIGHT (154 lbs.)

	No. of Portions	No. of Protein Calories
Breakfast		
1 small orange	½	3
2 shredded wheat biscuits	2	26
Vienna roll and butter	2	12
1 egg, soft, fried or poached	1	32
2 thin slices bacon	1	6
Coffee, cream and sugar	½	2.5
Total	700 cal.	81.5
Luncheon		
Ordinary serving beefstew	2	24
Tomato and beet salad with dressing	1½	15
2 slices bread and butter	3	28
Apple tapioca pudding, large serving	2	2
Cocoa, cream and sugar	1	4
Total	950 cal.	73
Dinner		
Cream of celery soup	½	8
Ordinary serving roast lamb	3	120
2 baked potatoes	2	22
Side dish green peas	2	50

FULL DAILY SUPPLY OF ENERGY FOR AN OFFICE WORKER OF AVERAGE WEIGHT

	No. of Portions	No. of Protein Calories
Breakfast		
1 small orange	½	3
Large serving of oatmeal	1	18
Cream and sugar	1	2.5
2 slices dry toast	2	28
Ordinary serving butter	1	0.5
2 eggs, soft boiled	2	64
Coffee, cream and sugar	½	2.5
Total	800 cal.	118.5
Luncheon		
2 small tomato and lettuce sandwiches	2	28
1 large glass whole milk	2	38
1 ordinary piece apple pie	3	15
Total	700 cal.	81
Dinner		
Plate of bouillon	0	0
Small serving rib roast	2	50
2 small potatoes with butter	3	20
Ordinary serving rice pud-		

Salad with mayonnaise ...	1	0
2 slices bread and butter .	3	28
Milk custard	1	26
Small piece sponge cake ..	1	7
Total	1,350 cal.	261
Grand total .....3,000 cal. with 13 per cent. protein.		

ding with cream	2½	20
Bread and butter	2	18
Demitasse black coffee ...	0	0
Total	1,150 cal.	124
Grand total ..... 2,650 cal. with about 12 per cent. protein.		

It will be clear from what has been said above that the requirements of the body for muscular labor in winter will depend on whether a person works indoors or out. Lumbermen who work in the north woods in winter probably require more food than any other class of laborers. At the opposite extreme, so far as external conditions are concerned, stand the men who work in factories, beside furnaces, etc. Their muscular work may be just as heavy as that of the lumberman, but their bodies are kept warm by artificial heat. The problem for them, as for ordinary laborers outdoors in hot weather, is rather that of removing the extra heat of muscular work.

Between these two extremes, naturally, are people who are subjected to conditions of all degrees of severity. It is impossible to prescribe a day's dietary which will fit all of them. We select a teamster and a foundryman of average weight. The former we suppose not only does the heavy muscular work of lifting boxes and cases, but is exposed to cold winds and rains. The latter does heavy work but is kept warm at his task.

A person who follows his natural craving will find himself eating more meat, especially more fat meat, in winter than in summer. This is not merely because fat meat contains more energy for the same weight than starchy foods, but because foods rich in protein and fat stimulate the processes of combustion by which heat is produced. For example, a day's diet consisting of nothing but lean meat would increase the heat production by about 30 per cent. The same diet consisting exclusively of starchy foods would increase it only about 5 per cent. This is the reason why laborers in the open crave meats more than do those who work indoors.

TABLE II

SAMPLE DIETS FOR A TEAMSTER AND A FOUNDRY WORKER

FULL DAILY SUPPLY OF ENERGY FOR A TEAMSTER OF AVERAGE WEIGHT			FULL DAILY SUPPLY OF ENERGY FOR A FOUNDRY WORKER OF AV. WEIGHT		
Breakfast			*Breakfast*		
	No. of Portions	No of Protein Calories		No. of Portions	No. of Protein
3 wheat cakes	3	45	Large serving oatmeal ...	1	18
with maple syrup	1	0	Cream and sugar	1	25

2 small chops (lamb or fresh pork)	2	36
French fried potatoes	2	22
2 slices bread	1	0
with butter	2	28
1 cup coffee	0	0
Cream and sugar	½	2.5
Total	1,150 cal.	133.5

Two slices dry toast	2	26
Butter	1	0.5
Large serving ham	2	66.0
2 eggs	2	64
1 cup coffee	0	0
Cream and sugar	½	2.5
Total	950 cal.	179.5

Luncheon

Plate of baked beans	3	63
with small piece fat pork	2	28
4 slices bread and butter	6	56
Rice pudding	2	16
Cup of tea with sugar	½	0
Total	1,350 cal.	163

Luncheon

3 sandwiches	6	56
with cold boiled ham (cut very thin)	1	28
2 crullers	4	24
1 pint whole milk	3	57
Total	1,400 cal.	165

Dinner

Large plate cream of celery soup	1	16
Large serving rump roast beef	3	180
Large serving macaroni and cheese	3	53
2 large spoonfuls creamed mashed potatoes	2	20
Side dish stewed tomatoes	2	20
Bread (2) and butter (1)	3	28
2 small baked apples	2	4
with cream and sugar	1	0
Ordinary piece sponge cake	2	14
Total	1,750 cal.	322
Grand total	4,250 cal.	618.5

with 14.5 per cent. of total in protein.

Dinner

Clear tomato soup	0	0
Large serving sirloin beef-steak	2	60
Large serving rice	2	20
2 large sweet potatoes	4	24
Side dish stewed onions	1	12
3 slices bread and butter	4	42
1 dish tapioca pudding	2	1
Cup tea and sugar	½	0
Total	1,550 cal.	159
Grand total	3,900 cal.	503.5

with 13 per cent. of total in protein.

That this energy-giving quality of foods is the most important function which they serve is apparent at once when we discover that at least four fifths of the dry weight of our food serves no other purpose than that of giving heat. The heat comes from the oxidation of our food and since the temperature of the air about us is nearly always lower—in winter very much lower—than blood heat, we are practically always losing heat by radiation and conduction. Merely to keep up the body temperature to 98° F., the temperature at or near which the living substance best performs its functions in every animal, is the purpose of the great mass of fuel which we are obliged to "supply" every day of our lives. To furnish the energy for the muscular work which most of us do requires relatively little and, strangely enough, to supply brain energy—intellectual energy, alertness and other purely psychic qualities —apparently requires no energy at all in the sense in which we have been using that term thus far. Experiments have been conducted on college

students while writing a very difficult examination, and it was found that no more energy was set free from the body than when they were simply writing nonsense. However, a very small part of the potential energy of the food always takes the form of electrical energy and electrical energy is manifested whenever nervous tissue (brain, nerve, etc.) is active. It is possible then that the reason no extra heat energy was given off from the body when the brain was working hard is because this electrical energy simply took the place of other forms of energy (like the secretory processes of glands, etc.), in which case it would not be correct to say that brain work is not done at the expense of potential energy. The subject requires much more study than has yet been given to it.

It will be evident from the discussion thus far that it is the energy content of the food which a person is concerned primarily to know in order to judge the economy of its use. Ordinarily if one takes care merely to supply himself enough heat energy and takes care also to eat a *variety* of food the other requirements will be automatically regulated by the appetite. Failure properly to adjust the energy supply to the actual requirements result in depletion which may subject one to disease, or, on the other hand, may lead to obesity.

But it would be a serious mistake to ignore the other chief purpose of foods—namely, their value as tissue builders and restoratives. While not more than one fifth of the dry weight of our foods find a permanent lodgment in the body, it is obvious that the functional activity of the tissues could not be kept up indefinitely without these constituents of which tissues are formed. Still less could growth of the body in early life be maintained.

Among these constituents the most important is that class of substances known to physiologists as *proteins,* exemplified by the white of egg, the casein of milk, the gluten of bread and *par excellence* the flesh of animals. The actual requirement of the body for these substances is much less than is ordinarily supposed. In starvation, when the body is living at the expense of its own substance, about 13 per cent. of its energy is derived from the breakdown of proteins or the nitrogenous substances. The remaining 87 per cent. is derived from the body fat and glycogen, which is the form in which the body stores up starches and sugars. Theoretically the body would be kept in perfect equilibrium then if the food contained 87 per cent. of the total energy in the form of carbohydrates and fats and 13 per cent. in the form of protein. In fact, many persons have found that they keep in better physical condition if they take somewhat less than 13 per cent. in the form of protein, for with a generous suply of carbohydrate in the food the waste of proteins from the body is considerably less than in starvation. The dietaries suggested above for various sorts of workers, however, have

been constructed on the basis of about 13 per cent. protein calories, to be on the safe side.

It would be most desirable, therefore, if the label on packages of manufactured foods were required to give also the content of protein in addition to the total energy value. This might be done in the case of oatmeal as follows: "This parcel is guaranteed to contain 2,000 calories of heat-value, of which 14 per cent. is in the form of protein," or, in the case of milk, "700 total calories, 16 per cent. protein calories." Naturally the milk would not yield 700 calories to the bottle unless it were high in cream. The relation of total calories to protein calories might also be expressed in the form of a ratio.

A law requiring the correct labeling of foods with reference to the energy content and protein content should result in a wholesome competition among producers and manufacturers to improve the actual food value and therefore their real economic value. At present the competition runs along the line of the appearance of food and mere flavor, which, although desirable, are not the most necessary qualities to be considered in the provisioning of our people. Coal and other forms of fuel for our boilers and automobiles we must take as we find them in the earth. The only way in which we can improve their quality is by refinement, which costs nearly as much as we gain. But in the matter of fuels for our bodies there are immense possibilities of improvement without increasing the cost a particle. The fuel value of a food crop depends upon the power of the plant to utilize primarily the carbon dioxide of the air and the water of the soil in the formation of sugars, starches and oils. Under the stimulus of the sunlight the energy of the sun is stored up in roots, grains, etc., and is not lost until the food is burned in the animal body. So long as air and water and sunlight cost nothing an improved variety of corn or wheat or oats or rice which would yield more energy should be produced as cheaply as those we are now living upon, except for the extra thought and work of selection which might be involved. But the stimulus to produce more for the money for the sake of larger sales is exactly the sort of stimulus we want the food manufacturer to have.

A standard of purity in this sense ought to have the effect also of emphasizing the expensiveness of animal food *as a source of energy* as compared with vegetable food. For when the corn grown in one field is fed to an ox in another the ox dissipates fully nine tenths of the energy walking about the field and stores in his body for our use as food only the other one tenth. Hence to get our full energy requirement in the form of beef even the cheapest cuts would cost us at least ten times as much as it would if we ate the corn meal. This is assuming that the cost of *preparing* the two kinds of food for the market, and finally for the table, is the same. The illustration is used only for

the purpose of emphasizing the fact that animal foods *as a source of energy* are necessarily more expensive than plant foods. *As a source of protein* the comparison would not be so much to the disadvantage of meats.

Of course it is realized that as matters now stand a great deal of our food budget is spent for pure flavor. Flavor in the broad sense is "anything which adds the element of pleasure to a meal." Chemical flavor which affects the olfactory organ or the taste buds serves a useful purpose at times in stimulating the flow of digestive secretions in anticipation of a meal and at times it serves a harmful purpose in causing us to overeat. The appearance of the food either in the parcel or on the table may serve as flavor. The kind of service, the presence of good company or even music come under the same head. If one can digest a meal only when accompanied by these latter kinds of flavors they are perhaps justifiable, but from the standpoint of the national welfare they do not deserve much consideration. Appreciation of food and the full physiological effect of flavor are obtainable by the simple device of getting thoroughly hungry before we eat.

The writer once had occasion to compare the actual food value of a dinner served at "Joe's" on Third Avenue for thirty cents and a five-course dinner served three blocks further west at a cost of three dollars. The advantage in actual food value lay with the former. The difference in cost was due entirely to "flavor."

The state universities of the wheat and corn growing sections of this country with the help and encouragement of the Department of Agriculture have already inaugurated an enthusiastic campaign for the production of better wheat, greater yield of corn per acre, and improved varieties of other food products. The classes in domestic science in public schools are learning food values as few of the present generation had any opportunity to learn them. Similar instruction has been given to working girls in the settlement houses. The time is certainly not far distant when the food manufacturer must keep pace with this rapidly increasing knowledge of food values and must make it possible for the housekeepers to know exactly what energy is stored in the food they buy. Some states, New York, for example, require cattle foods to be so labeled now. Human food may contain anything so long as it is "pure."

The government might well establish a classification of foods such as: (1) Foods which are wholly or chiefly energy-producing; (2) foods which are wholly or chiefly tissue-building and (3) foods which are of use chiefly as flavors. In the first class would belong sugar (which is usually thought of as a flavoring material), cornstarch, olive oil, butter, etc.; in the second would belong eggs, meat, cheese, etc.; and in the third would belong pickles, catsups, sauces, tomatoes. Foods which in

reality belong to more than one class, as milk, oatmeal, green beans, etc., could be assigned according to their analyses and according to the judgment of a referee board of physiologists, which would then have a constructive economic function to perform instead of a reviewing function which has been discharged by the Remsen Board; for to determine the real physiologic and therefore the real economic value of certain foods would require long and careful experimentation. The regulations as to labeling would naturally be different for the different classes.

Obviously there should be no relaxation of the present vigilance of the law as to preservatives which have been proved harmful, nor as to the permission of unwholesome constitutents nor as to the presence of adulterants—meaning by that term anything which reduces or impairs the food value. But the bureau of chemistry of the Department of Agriculture should be enlarged into a bureau of food economics so that its function should become more constructive in the sense in which the bureau of plant industry and the bureau of animal husbandry is more economic. It has become a truism that the government pays more attention to the health of pigs than it does to the health of men. Unless we mistake the spirit of true progressivism this will not properly express the functions of government a generation hence. A very material advance, educative in its influence and highly economic in its results, would be the establishment of this new standard of purity in foods.

A PROBLEM IN EDUCATIONAL EUGENICS

By Professor CHAS. W. HARGITT
SYRACUSE UNIVERSITY

THE flood of current criticism which has been directed against our educational system in general and that of higher education in particular is too obvious to call for special emphasis. While much of it has been exaggerated and some even hysterical, still there is not lacking a considerable body of really sane and timely criticism to which no true friend of advanced learning dare close the eyes. The college in particular has come in for some of the sharpest arraignment of recent years. One may discount the rather indiscriminate criticism of Mr. Crane and others of similar type, but he must face frankly, and answer with equal frankness, strictures which have come from such sources as the Carnegie Foundation, ex-President Wilson and others equally capable.

It is no part of the purpose of this paper to undertake to directly review in detail this discussion; but rather to inquire into certain conditions and methods of current educational philosophy, its ideals and aims, with the hope of directing attention to possible methods of scientific betterment.

It is charged that our educational work has failed to add to earlier literary, artistic or cultural power; that no American scholars are among the recipients of the Nobel prize; that there are no modern peers in literary distinction of Emerson, Holmes, Hale, Longfellow, Lowell, *et al.* These are grave charges if true. What is the answer? Is answer or explanation forthcoming? Surely it can not be said that interest in literary matters has languished, for the multiplicity of literary activity has not only not declined, but greatly increased, as expressed in the new magazines, journals and books which issue in veritable floods. But may not these facts of multiplicity of interest and activity be a sign of the very decline or failure which is charged? Granted that such may be the case; granted that such multiplicity and intricacy of intellectual life has placed an added burden upon student and literary devotee in the added necessity of larger and more varied preparation for such a career; granted that the enormous extension of scientific, historical and philosophic activity has had a disturbing effect upon the purely artistic or literary achievement, the further query arises, is this peculiar to American conditions? Is such a handicap essentially more serious to the American student than to the European? In some degree it may be so; for one finds in the German schools, for

example, that more of these preliminary or preparatory studies are disposed of before entering the professional career. Further, in the mastery of languages the foreign student seems to have, whether from inheritance or local conditions, a readier facility in rapidly acquiring usable command of these subjects. But with all this granted, is it quite sure that we have found a real cause, or merely an excuse for existing conditions? It is a condition and not a theory which confronts us and we can not afford to confuse the problem by any false lights, however alluring such a method might be.

However, it is not so much in the matter of actual difference in the relative status of these pupils in school achievement at a given age. It is rather in the matter of attitude toward things scholarly. One has not to go far into an inquiry to assure one's self on this point. Again and again has the writer heard and seen such expressions as "Don't let your studies interfere with your college duties," "fraternity is more important than scholarship," "only grinds pay any attention to marks," etc. Furthermore, it is rather evident that comparatively few give especial effort to achieving scholarship honors, such as prizes, Phi Beta Kappa, etc. Only rarely does one notice any emphasis in college papers of fellowships, research achievements, etc. One misses the eager passion for scholarship for its own sake which forms so dominant a place in the educational history of earlier days. The impression can not be escaped that the student attitude the country over is rather dominantly as intimated above, though it may be more open and avowed in certain sections than in others. "Stover at Yale" is not pure fiction!

Various attempts have been made to find some adequate explanation of this condition. For example, the dominance of commercialism has been assigned as a factor in this attitude and is involved in the scholarly decline. Let it be admitted that in this there may be a grain of truth, yet it is wholly inadequate as an explanation. We hear it over and over again that scholarly ability has a distinctly commercial value. Now if this be so then one ought to find a growing importance attaching to the highest possible standards of scholarship and educational achievement. But the obvious lack of just this is the very problem which confronts us.

Again, one finds emphasized the dominance of athletics, and the social dissipation in college affairs as responsible for divorcement of the more serious and primary considerations. And these express an undoubted element of truth; but again they are not the whole of the matter. They are but symptoms; the real trouble lies deeper and must have more critical concern.

To the mind of the writer the root of the trouble lies in our present-day educational methods. And one of these involved is what may be called *indiscrimination*. In our zeal for education we have been disposed to regard it as the one panacea for every social and civic ill. This is emphasized in such phrases as "education the foundation of

democracy," "the public school the hope of our country," etc. These catch-words may have important values, *e. g.*, they may serve the campaign orator some fine phrases, but let us look a bit deeper than even these.

Perhaps as a reflex of that other half truth, "All men are created free and equal," has come the general conception that education is the common privilege of all without distinction; that it becomes a magic wand able to dispel the seeds of incapacity, imbecility, criminality or even immorality. In a word, we have been taught to regard education as *creator,* rather than helper, guide or *cultivator.* No one expects his gardener, however skillful, to supply a superior product from barren soil or defective seed. Now let it be given all possible emphasis that back of culture must be a capable brain; and that this element of capacity is rooted in the physical basis of life itself—the *germ plasm.* These are at once the soil and seed for our mental gardener to work upon.

Long ago have we learned the fundamental lesson here predicted as it relates to the school of husbandry. The breeder is first of all a *discriminator.* He knows what he wants, and he knows that in only one way may he have it, viz., by patient and persistent *selection;* and only those factors which measure up to his standard shall have any place in his school. Others may serve as bearers of burdens—as dray horse, or plodding ox; but they have no place in the stud or in that school destined for a higher product. Our husbandman has learned his lesson from that severe mistress of all progress, mother nature, whose rule is that of *fitness.* Of the product she has said "*very good.*" The price may be high, above the rubies or mere marks, but its cost is well worth while.

Education and Selection.—Fundamental in Darwinism is natural selection, the counterpart of the artificial selection of the breeder. In nature it is a process of sifting, an elimination of the unfit through the rigors of the struggle for existence. Of its reality and efficiency in a state of nature there can be no doubt; though this does not imply that it has been the only method in operation.

As in social matters, so in educational methods, we have largely disregarded nature's method of selecting the fittest. On the contrary, our standards, whether of school or college, have been adapted to *mediocrity.* There has been a leveling down whenever the poorer pupil seemed unable to keep up. To be sure, in some instances the poorest have been returned to a lower grade, but rarely the *average poor.* In technical schools there has been less of this compromise, but it has not been wholly lacking even there. The effect has been to place a premium on mediocrity, just as has been the operation of a similar method in trade-unionism, and its sequence has been to a similar end—discouragement of initiative, independence, highest efficiency, and hence highest achievement.

It may be questioned whether the glorification of our educational ideals, and the formal aspects of it in particular, has not been greatly overdone. In spite of more than a century of its trial the per cent. of illiteracy is still large. This I believe to be due to the fact that there has not been allowed to operate more freely the process of selection. Not all children are fit for formal education. They have no business in either school or college, except in the former for the merest rudiments of learning. For them the apprenticeship, the trade-school, the vocational fitting, is that through which nature may afford some chance for a place. Many a boy should never be encouraged to go to college, and would not if any pains had been taken to look into his mental pedigree. He is sent in many cases out of mere fashion, a sort of social exaction which has for him only a social significance, or value, wholly beneath the aim of a college standard of any real dignity or worth. And as in the school, only more so, his presence involves the same low and compromising standard and reaction upon all concerned.

Let the gauntlet be thrown down without hesitation or apology—Distinctly academic culture, education for scholarly ends, *is not for all.* Aye, more, the ordinary *school* is not for all. Is this akin to treason, a direct challenge of the compulsory school laws? I do not overlook the beneficent aim of these laws. No more need one shut the eyes to another code, that for prevention of cruelty to animals. To how many of us has it occurred that occasion for the latter may as often be found under the former, or in other words, that truant officers and a system which makes them necessary are as amenable to the latter code as are those who torture horses or beat helpless wives? The cruelty of which I protest is that which thoughtlessly or ignorantly grinds every intellectual grist through a common hopper. The schools do not differentiate, teachers do not discriminate between matters of quality and quantity as mental factors. An expert in nervous disorders said in a recent address before a public assembly in Syracuse that "New York State schools contribute a larger quota to the insane asylums than any other agency." This might be variously construed, but surely it should give us pause in our zeal for compulsory education. But these laws are not designedly vicious; they only express misapprehension, they fail to discriminate.

Galton has shown beyond reasonable doubt that genius follows the same laws which control other phases of development. Indeed the earlier pioneer work of Galton blazed out the path which our later experimental methods have demonstrated, over and over again, to be now almost a highway, so clear is its course, so readily followed. Concerning this very matter of discrimination and selection he made bold to declare:

> I believe that if the eminent men of any period had been changelings when babies, a very large proportion of those who survived and retained health up to fifty years of age would, notwithstanding their altered circumstances, have arisen to eminence. Now if the hindrances to success were very great, we should

expect all who surmounted them to be prodigies of genius. The hindrances would form a system of natural selection, by repressing all whose gifts were below a certain very high level. . . . The hindrances undoubtedly form a system of natural selection that represses mediocre men, and even men of fair powers. . . . If a man is gifted with vast intellectual ability, eagerness to work, and power of working, I can not comprehend how such a man should be repressed. (Hered. Gen., p. 38, etc.)

Eugenics.—No more fundamental and commanding factor of modern biology is current than that of *heredity.* This has been long understood in its applications to various details of husbandry. Only of late has it become fairly subject to control and direction. Nearly ten years ago in an address before the Association of Academic Principals I gave expression to its educational implications in the following words:

Of all the equipments which go to fit pupils for the larger life before them none is more fundamental and imperative than that most vital of all biological factors—generation and heredity. If the highest level of human vigor and perfection is ever to be realized it must be by critical regard for, not defiance of, those simple and fundamental laws of biology which underlie heredity in generation. How long shall we continue to look with admiration and pride upon the rich fruition of an intelligent application of these laws to the endlessly varied products of field and stable, and at the same time pretend to bewail the endless lines of human degeneracy, pauperism and imbecility? Just so long as we ignore or defy the potency of these same laws in human generation!

It was in the light of just this truth that Dr. Holmes in answer to the query "when should a child's education begin," replied, "one hundred years before it is born"! And in a somewhat facetious paraphrase of the idea a later writer has said, "In the light of science it is up to children to be extremely cautious in selecting their grandparents." Waiving all the apparent paradox of the one, or the cynicism of the other, the present message of biology to every sane and serious man or woman in relation to progeny would be similar—due attention to selection of children. If the Roman adage, "a sound mind in a sound body," has any significance for education to-day it is just in the above sense. It is strangely significant that Plato conceived a similar ideal as the basis of his Republic; and had he known as do we to-day the directing and controlling power of *heredity* that Republic, instead of an *Utopia,* might have been an abiding *reality,* as glorious as the imperishable art and literature of its golden age!

Let it not be insinuated that eugenics as a program is as utopian as Plato's unless forsooth one turn skeptic concerning all laws of life. In the language of a recent authority

We may enunciate as a law of social evolution that a race possessing social culture will be victorious in the struggle for existence over a race devoid of social culture, the physical strength of either being equal. But it would be a grievous error to suppose that social culture by itself is any guaranty of stability. Athens had social culture unequalled by any of its rivals; but Athens fell. Social culture without biological fitness is as useless as biological fitness without

social culture. The law may be stated as follows: Biological fitness is to be estimated not only by the capacity of physical endurance, but by the capacity of reproduction, by the capacity of adaptation to new conditions of social life, and by the power to resist the importation of foreign vices and diseases. (Chatterton-Hill, p. 358.)

Pearson postulates two fundamental biological conditions as to human betterment:

1. That the relative weight of nature and nurture must not *a priori* be assumed but must be scientifically measured; and thus far our experience is that nature dominates nurture, and that inheritance is more vital than environment. Environment may and does modify the bodily characters of the existing generation, but not certainly the germ plasms of the next generation. At most it can provide a selection of which germ plasms among the many provided shall be potential and which shall remain latent.

2. All human characteristics are inherited in a marked and probably equal degree. If these ideas represent the substantial truth, you will see how the whole function of the eugenist is theoretically simplified. He can not hope by nurture and by education to create new germinal types. He can only hope by selective environment to obtain types most conducive to racial welfare and to national progress. The widely prevalent notion that bettered environment and improved education mean a progressive evolution of humanity is found to be without any scientific basis.

Improved conditions of life mean better health for the existing population; greater educational facilities mean greater capacity for finding and using existing ability; they do not connote that the next generation will be either physically or mentally better than its parents. Selection of parentage is the sole effective process known to science by which a race can continuously progress. The rise and fall of nations are in truth summed up in the maintenance or cessation of that process of selection. Where the battle is to the capable and thrifty, where the dull and idle have no chance to propagate their kind, there the nation will progress, even if the land be sterile, the environment unfriendly and educational facilities small.

The growth of the eugenics movement, both in Europe and America, within the recent decade is one of the most hopeful signs of the day, and far more eloquent than mere words or theories. Its intrinsic value for education is unmistakable. Herein, as I see the problem, is an open field for social betterment of the highest type, which in itself is of large promise as a basis from which it is not too much to anticipate means for augmenting any unit character of intellect as well as body. Just here is the hope for that increment of power, both innate and cultural, adequate for recovery of lost arts, and for carrying forward the race to higher achievement in every department of endeavor. If great poets, artists, statesmen and prophets are *born* not *made,* why not set into operative activity the only machinery through which such divine birth-heritages may become realities?

The problem is not occult. It is so simple that boys and girls may learn it even in the nursery, surely in the school. If a state may charter its special train in an educational propaganda to teach farmers the

lesson of selecting seed corn; if a state may spend hundreds of thousands every year for exhibitions of blooded stock, the triumphs of horticulture, the fleetness of the race-horse, may it not be worth while to ask an equally serious consideration of the same state and its citizens to the no less equally important problem of how to select and improve the seed destined to yield its fruition in human brains? And on the other hand, lauding the laws which warrant the slaughter of tuberculous herds, and the common sense of the farmer who relegates his scrubs and dwarfs to the shambles, what are these same sensible people doing toward a similar process of eliminating defective and unprofitable human stock? Almost nothing. *Almost!* It is matter for note that already nearly a dozen states have taken steps to cure some of these human blights. There is not time for details, but they exist. Such are glimpses of facts all too common and dominant. They cry for attention and intelligent treatment. They constitute in a special sense an educational problem the importance of which is beyond computation. It is *our problem;* what is to be our attitude?

Educational Eugenics.—It has seemed to me for some time that there should be found an application for the principles of eugenics in the work of education in general, and for that of higher education in particular. In seeking light on the problem I have submitted certain queries to a considerable number whose work or concern in such matters I know to be great enough to warrant inquisition. For example, to Dr. Davenport I put the following:

> I have long felt that for some reason we are failing to get the best results from college training, due in part, as I believe, to the fact that instead of affording opportunity and stimulus to the capable student, to the man of brains and fitness, the dead level of mediocrity is a constant check on just the man who could profit by it. We level down to the average man or below, and the capable fellow, unless selected by individual interest, is left to drift in idleness or worse. Can there not be devised some means whereby the incapable may be deflected from a college course? Why may it not be practicable to devise a scheme of entrance tests whereby some sort of mental pedigree may be made evident? Why not include pedigree examinations as a part of the medical examination now generally exacted?

To another was asked this additional question:

> Can not a means be found for giving to eugenics a distinctly educational direction as well as the conventional physical? The crucial query is *How to get at it?*

To still another:

> American education has been recently designated as a *Proliferating mediocrity.* How can this charge be refuted? What is the way out? Is it not possible to secure some sort of family-school-pedigree record as a basis for education?

To these varied inquiries various replies have been received. Some have been extremely suggestive, others have been conservative to the point of the worse than helpless. For example, one in reply says

I am sorry that I can not be of help to you in this matter, in which I think you will find yourself a voice crying in the wilderness with very few to heed. All the same, I hope you will set up as big a cry as you can, and even if I am not able to join you in that, I shall be glad to applaud your efforts.

Another says:

My theory in outline is that there should be compulsory examination for every student in college. This examination should have reference not only to heart and lungs, to see if the man will make an athlete, but should comprehend a look into history and heredity, and determine without question the presence of any sort of infectious disease. Such an examination would, of course, exclude some students from entering college, but that would be well. . . . I am in hearty sympathy with your plan, and should urge you by all means to organize it as an integral part of your department.

In a later letter the same writer said:

I am interested in your eugenic program. No doubt there is much wasted energy in every educational direction. Perhaps there is more of it wasted in mediocre human material than in any other direction. The results, of course, are bound to be mediocre. Still it is a question with me whether any other method can be adopted. . . . However, I believe thoroughly that there should be some selective process applied to the student material that applies for admission to the freshman class.

Another response will be briefly cited. Dr. Goddard, chief of research in the Training School for Backward and Feeble-minded Children, New Jersey, writes:

I should say emphatically that such a plan as you hint at ought certainly to be developed some time. It is probably rather early to do very much at it, since the whole subject is so very new. However, some things are already visible. It is, for example, entirely practicable to eliminate all the mental defectives by means of the Binet scale and furthermore to mark those who are merely backward, those who are average and those who are precocious. We need some method of measuring intelligence beyond the period previous to adolescence, the Binet Measuring Scale reaching only to 12 years of age. You are entirely right when you say there are large numbers who should never enter college. I do not know why the inquiry into the family pedigree would not be a valuable thing in considering the admission of a child to college. While it would undoubtedly not be safe to base everything on that, yet it would contribute very materially to an understanding of the case. At present I do not believe we have enough data to enable us to interpret the results we should find.

A later word from Dr. Davenport afforded special encouragement. He says:

I hope your plan of getting pedigrees of students as a part of the medical examination would be carried out. As a teacher I always felt that I knew too little about the incipient qualities of my pupils. Why should a teacher begin in the dark when he might begin with a knowledge of the student's probable potentialities. The more I contemplate your plan it seems to me if it can be carried out that it will mark an epoch.

Enough has now been suggested to warrant the reflection that our entire educational program, its ideals, aims and methods is faulty at many points, and in not a few absolutely untrue to any consistent application of biological principles. When we reflect upon the course through which our educational philosophy has come it is not surprising that there

should have been error, that something of tradition has held a sway beyond reason, and that much of existing methods are an inheritance from an outgrown past. It is not to be wondered if criticism has arisen. The wonder is that it has not come sooner and been more fierce. If one compares the civilization of even the most enlightened nation of antiquity with that of the present day; if with this survey he includes that of prevalent ideals and methods of education; if, indeed, he compares conditions in pagan Greece and Rome with the latter under the sway of the monasticism of later centuries, it will be less surprising that there arose the condition known as the "dark ages," which dominated both state and church, and school as well, for more than a thousand years. Without indifference to the good which may have endured in spite of dominant ills in the educational ideal and aim of those times it is still high time that they be estimated at their real worth and discounted according to their inadequacy in relation to present-day conditions and needs.

Through just what means the desired betterment may best be realized may still be an open question. There are those who will continue to regard it as a philosophical problem. But there are others, and their numbers are multiplying, who look upon the problem as one open to scientific and experimental solution. The writer assumes the biological point of view without hesitation or apology. He believes that whatever ideals one may assume it must be more or less evident that man, the subject of these ideals, is involved in those common relationships and laws which condition all organic nature. His growth, both physical and mental, is also conditioned by the same laws. Furthermore, it is probably beyond serious dispute that man in his entirety—body, mind or spirit—is a unity; that all his powers are so correlated that it is not possible for us to isolate them for any such artificial object as that of conventional education. The older notion of mind as an entity, distinct and independent of body or natural relations, an occupant of the "tenement of clay," may still be a fruitful theme for the metaphysician, but it is without significance in any sound philosophy or science of education. Whether one may accept the purely neurological view that all mentality is potential in the metabolism of nerve cells he can hardly doubt their intimate correlations.

Therefore, whether for better or worse, under the biological assumption, the methods of education, whether of body or mind, whether for mental or physical efficiency, must be those of the living world. In this view there is nothing essentially novel. In many of our educational processes, sometimes consciously, oftener otherwise, there has been at work these vital principles. Galton's appeal has been already cited. The whole program of eugenics is but another aspect of the application of the same conception. With this much accepted let attention be directed without further digression to the main aspect of our problem,

namely, a provisional program of educational eugenics. Granted the clearly defined program of eugenics in its primary relations, may a method be devised by which the same principles may be made operative in the realm of education? In other words, can this biological method which promises so much for the race in its physical, social and other respects, afford a reasonable basis for similar hope concerning mental and spiritual betterment? May we find in it the promise and potency of a higher and better type of scholarship than that of the present or past?

I have referred above to "a *provisional program*" to be directed to these ends. In an attempt to frame a scientific hypothesis of heredity Darwin designated his attempt as "provisional." It was open to serious criticism at first, and it is hardly too much to say that it has only a historic interest to-day. With such a fate for *that* provisional hypothesis I am not vain enough to anticipate an immediate and unchallenged acceptance of views on a subject greatly more complex.

But is such a program desirable or important? Are educational conditions such as to call for an experiment of the sort which in the nature of things must be more or less an experiment? These questions are important and merit serious attention; but to my mind they must be answered in the affirmative. The program is important and worthy of whatever test or experiment may be called for in its solution. It seems rather certain that the tide of criticism already noted is such that there should be no evasion in giving to it the consideration its importance warrants. Furthermore, it is not too much to aver that existing knowledge concerning biologic laws and principles is such as to call for searching revision of existing methods of all phases of education. It is absolutely impossible to differentiate between growth or development as related to body, mind or spirit. It was once thought that such distinction was obvious as related to animals and plants. To-day such a view is impossible. The fundamentals of life are the same everywhere and always. And the growing child, in every aspect of its nature, is amenable thereto; and every phase of its development should have the same intelligent biological direction as is given to other living things. Some may be forced, while others must as certainly be restrained, or absolutely transplanted and developed under a different environment. A method applicable to the precocious would prove fatal to a mental defective. And now, that we have the ready means of differentiating these varying grades of mentality, it can hardly be short of folly to decline to utilize them thoroughly. Our school authorities have been ready to take advantage of every means by which these ends may be conserved. For example, in this state steps have only just been taken to care for any such physical defects as may impede or embarrass the pupil in the school. This has been undertaken jointly by the boards of education and health. Examinations of eyes, ears, nose, teeth, etc., will

be made by special teachers under a district superintendent, and all such records will become the permanent property of the state board of health.

A School Census.—Here we have the first important step toward the establishment of a definite school census. It is admittedly only a first step; but when it shall be recognized that it is quite as important that the same critical attention be given to defects of mind as to those of teeth or eyes we shall have taken the step which more than any other can redound to educational betterment, and at the same time prove a more effective measure for prevention of cruelty to the human animal than that at present in vogue. With such a school census at command the work of the teacher becomes at once intelligent and at the same time free from the apprehension which must ever haunt one whose problem is rendered obscure by ignorance as to actualities in constitution of the pupil's mental capacity. The Binet scale has been sufficiently tested to render it a fairly trustworthy method of judging potential, as well as actual mentality, and no valid objection has been made against its use. Such a method correlated with such careful family pedigree as might readily be made an obligatory part of our official vital statistics would form a school census of the very first importance in relation to educational betterment and progress.

Difficulties.—The problem is not simple. There are difficulties, and some of them serious. But they are not insuperable. There is that associated with the ideas of family privacy, those skeleton closets where disagreeable things of body or mind are scrupulously hidden from the public view. While we may not lightly moot these objections, at the same time the state and society have rights involved which are no whit less sacred than are those of the family. As a social unit the family must not be permitted to foster conditions which may menace the larger complex of society. These rights are invaded by the board of health, by the life insurance company, by marriage permits (not as yet widely effective); why have not the guardians of mental health and efficiency an equal right to such knowledge? But let it be made clear that such a census need not be a public bureau. The school principal or superintendent is surely as trustworthy as is the city clerk or insurance agent and may be made amenable to any honorable discretion in such matters. Other difficulties may be raised, but none so far can be foreseen of serious concern; surely none more grave than the above. It is not probable that impediments, of whatever character, can long obstruct a searching inquiry into a method having even a reasonable probability of value from receiving a fair test in an impartial effort to advance educational methods by rendering them more scientific and efficient.

A Provisional Scheme.—As an outline of a method of educational eugenics the following seems both rational and workable:

1. Adequate vital statistics. These should include an authentic record of data touching (*a*) birth and parentage; (*b*) physical characteristics, health, development; (*c*) temperamental peculiarities; (*d*) mental traits, or predispositions; (*e*) moral characteristics. Critical data covering these matters should be made obligatory upon parents or guardian. Such data would be of inestimable value to the teacher at every step in the course of instruction and should cover the period from birth to school age.

2. A school census. From the time of school entrance and through the entire course of the grades there should be a permanent record of (*a*) rate and character of progress; (*b*) mental aptitudes or peculiarities; (*c*) temperamental or moral traits. During this time there would be ample opportunity for application of the Binet tests of mental capacity. Such a record would afford a real insight into the mental pedigree, which, compared with that of the nursery period, should afford some insight into hereditary antecedents.

3. A high school census. Upon entry into the high school its staff would have at command a body of fairly trustworthy data as to the general character and capacity of every pupil. It would thus become practicable from the first to advise intelligently each one as to the type and character of course to be pursued, *i. e.*, whether academic or vocational, literary or scientific, or whether discouraged concerning either. At any rate, both principal and teacher would be advised in advance as to prospects and probabilities, and thus forearmed to meet the issues. Thus qualified we should be saved from an expedient recently invoked of lowering the passing grade of the high school in order to encourage (?) dull pupils against truancy or abandoning the course, and then defending the method by the assertion that the apparent lowering of the standard was only such in form, that examinations would be made correspondingly more difficult! Such a subterfuge calls for no special comment! As in the grades, so in the high school, a similar record should be as rigidly kept, adding such data as the advanced age of the pupil might naturally afford, *e. g.*, as to prospective vocation, peculiarities, moral traits, etc.

4. A college census. Already there is much available data touching various aspects of actual progress and subsequent history. Much more is needed along these lines. There has been far too much boasting concerning subsequent capacity of college-bred people. This has lent itself effectively to the college agent or president in his endless appeal for resources, for students, etc. Let there be developed a thoroughly reliable body of facts touching every aspect of college or university pretension. Let it include data no less critical concerning social, athletic, fraternity affairs, and followed later by equally critical details as to subsequent professional distinction.

The scholastic pedigree furnished by the applicant for admission to

college which the high school affords would serve quite as useful a purpose to the entrance board as is now served by the examination or certificate; indeed, in most respects a much higher credential than the latter. But beyond this ordinary entrance tribunal there should be one of still deeper importance. If the earlier school life has been largely one of grounding and discipline the college should be distinctively one of discrimination and selection. There is no more expensive and important institution in human society than the college and university. It is obviously unfair to add to the constantly increasing burden for supporting these social institutions by adding to their obligations the thankless task of educating the uneducable; cultivating a defective soil; producing a superior fruit from degenerate seed. Yet such is the present program.

Let there be added to the entrance examination already in vogue an inquiry into the eugenic pedigree of every entering freshman. This will involve no additional machinery; simply a better type of medical inspection; one which will not stop short with a test of lungs or heart or musculature; but will inquire into antecedents touching mental and moral as well as physical traits. That such is not so radical a matter as might at first sight appear, note the following recommendation made to the board of trustees of a state university only a year ago.

"*A Chair of Individual Attention.*"—This sounds a bit vague, or worse, and it is not quite clear as to just what was involved in such a chair, but the following will afford some clue:

> To ascertain everything possible as to the antecedents of every student entering college, he (the professor) should know from pastor, teachers, parents and all qualified to testify concerning him, what his life has been from infancy through the kindergarten, the grades and the high school up to the time of his entrance to college. It would be possible for such an expert to learn something of the causes that have contributed to the previous failure or successes of the student. (*Miami Bull.*, 1911.)

Without attempting a discussion of this particular suggestion, or an inquiry as to just what might have been the aim, it seems fairly evident that *one* feature concerned was a more intimate personal relation with the student. The program herein proposed involves this and much in addition. That the personal concern is important is beyond all question; but that much more is imperative and fundamental is equally certain. It matters little just what *name* may be attached to such a chair. It might be designated the professorship of educational eugenics; or it might be called the chair of hygiene and physical culture; or any other of a dozen such. The point of real importance is that such a chair be created and placed on the same basis of dignity and independence as that of history or economics, and given opportunity and facilities essential to efficiency. To the writer no departure in educational progress is more imperative than that here proposed, and he earnestly anticipates its early realization.

THE PSYCHOLOGICAL FACTOR IN SOUTHERN RACE PROBLEMS

By JAMES BARDIN, M.D.
UNIVERSITY OF VIRGINIA

WITH the increasing complexity of society in the southern states, the Negro problem is taking on a correspondingly complex character, and is coming more and more into the foreground of southern consciousness. Immediately after the civil war—in fact, during the entire epoch in which the south was in the grip of reconstruction—the Negro did not give rise to the same problems that he does to-day; that is to say, the fact that he was a Negro was not the fundamental element in the situation; at that time, the problem most in the minds of southerners was the presence of the reconstructionists and the reconstruction governments, and the Negro was feared only because he was the tool and the weapon of the latter. But with the gradual rehabilitation of southern political liberties and the reestablishment of stable local governments, the period of economic and social expansion began in the south, and southern men, freed from the necessity of combating ceaselessly for political life and social integrity, set about developing the long neglected natural resources of the country. With this change in conditions and this alteration of profound interests there came a change in the status of the various groups forming the southern social organism. And the Negro, no longer a political bête noire, began to come to attention in a more normal way as an organic member of society; and southerners, secure in their hard-won political and social ascendancy, began to be interested in him as a Negro and to attempt to bring about his better adaptation to southern social institutions. This attempt on the part of southerners to help the Negro adapt himself to southern social conditions has a peculiar significance to the average southern man; it implies an attempt to increase the social efficiency and the economic value of the Negro rather than his elevation to a higher social rank. Thus, in the thought of the average southerner, the uplift of the Negro has a radically different significance, usually, from that which it has in the thought of those living outside the south, who do not altogether understand southern social conditions.

First and foremost, the southern man is interested in raising the economic value of the Negro. To accomplish this various means have been adopted, all designed to train the Negro in things of practical usefulness. Concomitantly, the churches and philanthropical institutions are working toward the same end by attempting to teach the Negroes

how to live better, and thus increase their efficiency and insure their status as self-supporting, independent members of society. The Negroes themselves are working to accomplish this end in practically every institution maintained by them throughout the south. This view of the Negro problem, practical in the extreme, is the one generally held at present in the south. The ideal seems to be to force the Negro to earn a better place in society and political life by the sweat of his brow and the toil of his hands; which toil, it is confidently hoped, will be guided by a constantly increasing intelligence, itself the indirect fruit of his labor.

On the other hand, outside the south the Negro problem is generally viewed as not primarily an economic, but as a political and "social rights" problem. The aim of many, if not most, of those living outside the south who take an active interest in the Negro is to secure for him fuller political rights and wider social opportunities, believing that as restrictions are removed, the Negro's position will improve in every respect, and he will ultimately take his place side by side with the whites, on an equal footing and possessing an identical cultural equipment.

Whatever be the theoretical merit of these views, whatever be the results of their trial, whatever be the advantage of one over the other ethically, it can easily be seen that although they advocate almost exactly opposite methods, those who advocate them are striving to reach the same goal. Each group is attempting to help the Negro to attain a more complete civilization; and each is attempting to do this by trying to make the Negro absorb the white man's civilization and come into complete accord with the profound moving-springs of the white man's social sanctions.

Many writers have contributed to the elaboration of these prevailing views of the problem. Admittedly, all of them have as their ideal the creation through evolutionary processes of a state in which the whites and the Negroes live side by side, each group partaking of the same civilization on a basis of ethical equality, and each playing its part in government and society according to its ability. This bi-racial state, theoretically, should have a single civilization, common to and understood similarly by both peoples; this civilization—and here is the vital point—will be the civilization of the whites, which, it is assumed, will be inculcated into the Negroes and which the Negroes will absorb without sufficiently modifying it to impair its usefulness as a foundation for a complex, though organically homogeneous, society.

Underlying the conception of a state such as has just been described lies a more fundamental conception which is seldom formulated, but upon which the whole structure of theory about southern race problems is based. This conception may be stated in various ways; its boldest, most general, and most erroneous form is the hypothesis that "all men are equal"; a more moderate form is "equal opportunity for all, special privilege for none"; but the most comprehensive form, which contains

by implication very nearly all that is included in our thought upon the matter, is that "all men, when normal, possess the same capacity for intelligence and the same ability to absorb culture and to become civilized"; in other words, that all men are essentially alike mentally and morally, when viewed in the large, notwithstanding physical and physiological differences. The culture of any group of men, it is assumed, may be adopted by, or forced upon any other group of men, without effecting any revolutionary change in the culture. It is tacitly thought that while the processes of evolution have given one race a white skin and another race a black skin, have made one race relatively resistant to tuberculosis and the other relatively susceptible, and so on, the minds of both are alike—have not diverged as their bodies have in the evolutionary series—and that the mental processes of one may become, by proper direction, the mental processes of the other.

On conventional ethical grounds, the hypothesis of human equality can not be assailed. The Christian world, particularly that part of it which really thinks, is essentially altruistic, and this altruism demands that all men be given the fullest and most equal opportunities to get the best out of life. But it is seldom realized that this is an ideal, not a working formula; that it is, further, an ethical ideal, not a scientific one. Out of this misconception of the ideal of human equality have sprung many grievous and oftentimes dangerous fallacies, chief among which are two: (1) that all men possess the same potentialities for culture; and (2) that a so-called "higher culture" may and ethically should be substituted for a so-called "lower culture" whenever opportunity presents itself.

As has been said, each of these ideas has a basis in ethical principles. But both are fallacious when scientifically considered. Each assumes too much, and each tries to make out of an ethical ideal the scientific working formula for the uplifting of backward peoples. Neither takes into account that culture and civilization are as much the products of evolution as a white skin or a black skin.

Culture, in its broadest sense, is a phenomenon of race. Even in our more or less homogeneous western European and American culture, racial differences are to be observed; if this were not true, why should we take the trouble to call some people Germans and others Spaniards, some Danes and others Italians? Yet, despite these evident differences, western European and American culture is a definite, characteristic thing, and underlying it we recognize a common stock of traditions and general ideas which have come down through the ages "in the blood," so to speak. The white-skinned peoples of western Europe and America all have approximately the same origin, in that through the remote mixing of a few strains of blood the modern racial types were set; and since then the peoples of western Europe have given evidence of their biological kinship by displaying approximately similar reactions to similar

environmental conditions and to the influence of general ideas and movements of thought. Whatever variations have appeared in the physical and psychical types among the various peoples are due to differences in the mixtures of the original strains of blood, with the accompanying differences in the contributions of hereditary mental predispositions received by the respective peoples, plus subsequent adaptations to environmental conditions. But behind all the differences lies a common kinship of blood and of tradition, which has operated to produce the unit we call western European culture; and this racial kinship is the principal reason why it is not difficult for one group of western Europeans to adopt without revolutionizing it the culture of another group. Furthermore, as a powerful factor assisting in the formation and growth of this western European culture, and aiding constantly in keeping it homogeneous, is the fact that the several strains of blood, particularly in the higher levels of society where most of the productive thinking is done, are incessantly mixing, and there are being interchanged incessantly, through heredity, the mental predispositions peculiar to the groups thus crossing. The people of western Europe and the white portion of American population, for the most part, are a sort of "blend" of similar racial stocks, presenting similar though not identical biological characteristics; and the varieties of this "blend," expressed in such terms as "English," "Dutch," and so forth, are due to differences in the numerical relationships of the contributing stocks forming these peoples. So, too, western European culture is a sort of "blend" of cultures, and the varieties of this "blend" parallel the varieties in the physical characteristics of the various peoples.

The same statements apply to any other group of people presenting a special, characteristic type of culture. The Chinese are an example; they differ among themselves in certain respects; they are a "blend" of races and their present culture is a "blend" of cultures. Yet Chinese culture is definite, peculiar and recognizable, and it is essentially Mongolian, just as our culture is essentially European. Behind the differences among the various groups in China lie their common Mongolian blood and their common store of traditions, the influences of which have moulded them into what they are to-day. Exactly the same statements apply to the Negroes. They have, physically and mentally, definite and easily recognizable characteristics, indicative of a common origin different from our own, and expressed in a similarity of Negro cultures throughout the world.

The fact of race as a physical and mental phenomenon is evident to every one. The peoples of the world differ, and often differ fundamentally; and these differences are ineradicable as long as the strain of blood remains unimpaired. On the physical side, this principle has long been an axiom. "Can the Ethiopian change his skin?" asks Jeremiah. We can not, do what we will with environment, change to any

appreciable extent our anatomical make-up. A Chinaman's skin will remain yellow, a Negro's skin will remain black, no matter what we may do to alter them, so long as the races remain pure. The only way we can modify the color of the skin or the facial angle or the texture of the hair in any great number of individuals is by crossing with another race. And the product of this crossing, should it become permanent, is a different race.

From the point of view of psychology, on the other hand, we have assumed that this principle is not true. We know that we can not change a Negro's physical characteristics, so as to make him like ourselves, by bringing him to live among us. But we believe we can change his mental characteristics. In other words, while we are certain that we can not change the Negro's facial angle, we are equally certain that we can change his mental angle and make it like our own; while we consider it absurd to think that we can do anything to make the Negro's physical skin become white, we believe firmly that we can make the psychical analogue of his skin exactly like our own.

But is this a fact? Racial psychology says no. Mental characteristics are as distinctly and as organically a part of a race as its physical characteristics, and for the same reason: both depend ultimately upon anatomical structure. Racial mental-set, racial ways of thinking, racial reactions to the influence of ideas, are as characteristic and as recognizable as racial skin-color and racial skull-conformation. This does not mean that mental characteristics and superficial anatomical characteristics necessarily bear any relationship to each other, as has sometimes been assumed; that is to say, the shape of the head, the weight of the brain, the cranial capacity, the length of the arms, the arrangement of the muscles in the calf of the leg, do not determine mental characteristics: physical and mental characteristics are, however, parallel expressions of the particular evolutionary process which has resulted in the formation of a race; each set of characters is the specific result, in different structures, of the evolutionary process. Ultimately, mental differences must depend upon anatomical and physiological differences; but these differences are differences in the structure of the brain itself. If we are to assume any relationship whatsoever between brain and mind (and such a relationship, whatever it may be, certainly exists), we must assume some anatomical and physiological differences in brains if we are to account for mental differences.

The more the races of men are studied, the more certain becomes the evidence to show that races have characteristic mental peculiarities, which would serve to distinguish species and varieties almost as well as physical characteristics. In practical life, in jurisprudence, in language itself, we empirically allow for these racial mental differences. But we have never taken the trouble to study them nor to understand their

nature from a scientific point of view, and almost nothing is known about their potentialities.

Taking as a fact these mental differences, let us for a moment consider the possibility of their modification. It has been pointed out that mental differences must ultimately depend upon material anatomical differences in brain-structure; if we deny this, we instantly remove racial psychology from the field of science to that of metaphysics, and controvert all the observed data of physiological psychology; there must be some structural differences between the brain of a Negro and that of a white man, though such differences are admittedly very hard to detect by present methods. We know that it is impossible for us to modify anatomical structures at will; we can undoubtedly change them (within narrow limits, by selection of characters already present and the accentuation of these), but we can not make any two differing anatomical characters become exactly alike. Why, then, should we assume that we can modify at will the mental processes of a race, since these mental processes are expressions of a certain definite anatomical and physiological organization, which we know can not be altered save by the crossing of bloods or by the laborious and infinitely slow processes of evolution?

Yet, north and south, we wish to do this very thing, and to do it in its extreme form. For we are not merely trying to change the direction of the Negro's peculiar mental characteristics, and to improve them by selection among the elements already present—we are trying, on the contrary, to deprive the Negro of his own racial mental characteristics, and to substitute our own in their place, *at the same time keeping him anatomically a Negro.* That this is an impossibility follows after the former argument.

It will undoubtedly be said, by way of refutation, that the Negroes of the southern states have advanced and advanced considerably since they have been in this country. This is unreservedly true. But it is often forgotten that they have advanced as Negroes, not as anything else. They have adopted the form of our civilization and to a certain extent (due principally to the influence of language), the mould of our thought. But however much the form of the civilization and the mould of the thought resemble our own, the substance of both is different. The Negro has received much from us, and has profited greatly therefrom; but all that he has received he has modified in accordance with his racial mental-set, and his psychical reactions to the influences of our civilization are entirely different from our own, and will necessarily remain so as long as the Negro is a Negro. No matter how much we educate him, no matter how much we better his position in society, he will remain a Negro psychically as long as he remains a Negro physically. We may cause him to absorb the full, rich store of our cultural elements, but by the time these elements have gone through the channels

of his thought they will be profoundly modified, and they will take on a different meaning in the Negro's consciousness from what they have in the white man's consciousness. Concomitantly, these cultural elements will modify the brain of the Negro; but this modification will not follow the same pathways and will not give the same results as it would in the untutored brain, say, of a white child. The modifying forces acting upon the Negro's brain will have to start with an anatomical structure already formed and set by heredity, an anatomical structure different from that of the white race, which produced the modifying forces in question, and the final result in the Negro's brain will be determined and directed by this preexistent anatomical make-up. So that the brain and the consciousness resulting from the absorption of our culture by the Negroes will be a brain and a consciousness different from our own to the same extent that the Negro differs from us in other respects, and both will be characteristically Negroid in nature, not European.

It follows, therefore, that present ideals in regard to the "solution" of our Negro problem (ideals, as has been pointed out and which it is well to reiterate, resulting from the confusion of ethical and scientific principles) are biologically fallacious, and impossible of attainment. We can never make the Negro like the white man mentally. We can never have a bi-racial state based upon an identity of ideas and political philosophies in both races.

The Negroes will continue to progress, undoubtedly. But they will progress along the lines laid down by their evolutionary history. They will take our cultural elements and make them part of themselves; but they will modify these elements according to their nature, and when they have assimilated them, they will be our cultural elements no longer, but will be profoundly and permanently modified. The two races will continue to develop side by side, but the development can never be parallel—it must be divergent, even though its successive steps may perchance maintain approximately the same level, as long as the races remain pure. It will be like two men, thrown together by fortuitous circumstances, who start walking up the same slope toward the same hill-top; but because of differences in the nature of their interests, one goes east while the other goes northeast; each step will carry them closer to the top of the hill, but further and further apart.

This fact, rather than ethical theory, should form the foundation of American thought in regard to the Negroes and the Negro problem. The Negro as an intellectual being should be studied as a Negro—not as a potential white-man; and if we wish to help him, we should at least try to be sure that he is allowed to develop as a Negro in the freest, broadest manner possible, and to the full extent of his racial potentialities.

WOMEN IN INDUSTRY

By D. R. MALCOLM KEIR

DEPARTMENT OF INDUSTRY, UNIVERSITY OF PENNSYLVANIA

The Physical Effects of Wage Work

WOMEN'S efforts to obtain a vote have directed attention to other problems which confront members of their sex. Long hours of work in factories and stores and the evils of the sweat shop have been investigated, but little has been written upon the effect that working may have on women's ability to bear children.

It is said that the hue and cry over the work of women in industry is misplaced and overemphasized. Women have always been employed at the very same things for which they now draw wages. Since history has been recorded they have woven cloth, prepared food and borne burdens. The only difference between former times and the present is that most of this work was once done individually in the home, whereas now it is carried on collectively in a factory. Women are not doing men's work. They can not, for they are smaller, less agile, less strong. Rather it is true that men in spinning, weaving and sewing are invading women's sphere and crowding out the women. It is claimed that the work in mills is for no longer hours, nor under worse sanitary and hygienic conditions, than women's tasks have always been. A parallel argument is that scarlet fever is not a dangerous disease because it is no worse than smallpox. If it is true that there are 156 women sick for every 100 sick men in the cotton mills; if the sick-insurance societies of England, Switzerland, Germany, Austria and France report that women are ill oftener and for a longer duration than men; if medical authorities report that 40 per cent. of married women who have been factory girls are treated for pelvic disorders before they are thirty years old; then it must also be true that factory work has in it something that is more injurious to health than similar employment at home. When the labor is performed away from the domestic hearth new elements enter into it that make it dangerous. In the home the woman prepared the raw material for spinning, twisted it into thread and then wove the cloth. Each of these operations called for a change of position. In the factory the whole task has been so subdivided that each woman does only a very small share of it, and so she must stand or sit continually in one place. Such intense specialization permits no variety in the motions of the work, thus producing a monotony that is deadening. Furthermore, the number of machines to which a woman

must attend, and the speed at which the machines are driven are constantly being increased. Coupled with piece-work wages, the "speeding up" results in a nervous tension and strain almost wholly lacking in the domestic system.

Although a woman might work for long hours at home, she could stop when it was necessary to attend to her natural bodily needs. In the factory she has not that freedom, and the result is a whole train of ills.

As a quadruped the female suffered little handicap because of the functions peculiar to sex, except when actually carrying or nursing the young. But after mankind had learned to stand erect, her support was far from ideal. The bones of the ankle and feet are too small to sustain great weight. A woman's knee is not so well adapted as a man's to form part of a sustaining column. The muscles of the leg, too, have a shorter purchase than a man's, hence the leverage between the trunk and the extremities is less. The strain of support is transferred to the back. Thus any work which requires long standing for a woman is injurious. All the pressure of the body's weight is brought to bear upon a portion where the sex organs and others are crowded together, and produces a dragging feeling above and about the hips. Women performing such work are especially liable to congestion of all the organs enclosed by the hip bones, because standing and the habit of resting on one leg only, causes a narrowing of the hips. This narrowing is especially apt to occur because the greater proportion of women workers are too young to have become securely and permanently established physiologically before going to work. The average age for men at work is between 25 and 30, whereas the average age for women is between 16 and 20. In 1900 49.3 per cent. of the women were under 25 years of age. In the silk, knitting and hosiery mills there are as many girls between 16 and 20 years as all women over 21 years. By far the greater number of girls do not break down while they are at work, but after leaving the work for matrimony the deformities caused by the work become apparent. Specifically the uterus is very apt to be crowded out of place, or to be congested. Menstruation is made irregular and difficult. Factory women frequently stand at their work to within a few hours before giving birth to a child, with the result of premature labor. Miscarriages occur oftener among factory wives than in the general population. It is more frequently necessary to use instruments in childbirth among such women.

The mill hands are not the only women who suffer from long standing. The girl clerks in department stores are subject to the same conditions. Although 37 states require seats to be placed for clerks, there is no law enforcing their use. Many stores have a rule that clerks must stand at all times, because they look less alert when seated. Clerks on the first floor are seldom allowed to sit down. When sitting is permitted at all, the number of seats is inadequate for the sales force. In

addition to standing, clerks suffer from lack of space behind counters, which increases the strain of lifting and puts a further burden upon the pelvic organs. The secondary effects of long standing, among which are broken arches in the feet and enlarged veins in the legs, is to add to the nerve strain, and indirectly affects other functions.

Sitting in one position has an action similar to long-continued standing. Lack of exercise reduces the capacity of the lungs, and so they do not eliminate certain poisons from the body. Because the lungs fail to act the kidneys are forced to do extra work, adding to the congestion of the abdominal organs. Sitting augments constipation, a minor ailment in itself, but one which breeds more bodily ills than any other single cause that might be mentioned. This condition is very prevalent among working women because of their lack of careful personal attention. In mills and stores the toilets are often too few in number, unsanitary in condition and inconveniently placed. In many cases there is no separation for the sexes. In some stores and factories no employee can leave her work for more than five minutes. When in a many-storied building the toilets are not on the same floor with the worker this rule amounts to a prohibition. In other places girls must ask permission of men foremen or floor walkers to leave their work, a thing which many hesitate to do. When a store closes at 6 o'clock clerks frequently may not be absent from their posts after 4:30 P.M. Such conditions cause a partial paralysis of the alimentary canal, and abnormalities in the secretions, which puts an undue and constant strain upon the whole body. In women this strain is most apparent in functional abnormalities, hysteria and general anemic conditions. In addition to the restraint of sitting the indirect pressure against the abdominal organs by leaning over a sewing machine or against a desk augments the tendency to chronic inflammatory disease in the pelvis. The total result of long standing, or sitting in one attitude, is either absolute sterility or such organic disturbances as make child-bearing dangerous.

The second new element in modern industry is the monotony of the work, the unending recurrence of unavailing effort. It is difficult to trace any direct effect of monotony upon the more vital organs of the body. Monotony is a mental rather than a physical phenomenon. Modern factory work demands no feeling, no personal interest, no responsibility, nor inventive genius on the part of the worker. She does one thing endlessly, automatically. Work which demands nothing of the intelligence costs the intelligence more than work which demands too much. When only one brain center is employed the brain is more fatigued than if all the centers were worked harder. The result is either a stunting of mentality or an inordinate craving for excitement. The intimate association of the nervous system with the other functions

of the body insures the reflection of injuries to the brain centers in the disturbance of all other organs.

The monotony of work is linked to the strain under which it is carried on. In the knitting industry a girl now has to watch from two to ten needles instead of one. In sewing shops the needles make 4,400 stitches a minute. The operator can tell when a needle or a thread is broken or a stitch misplaced only by a variation in a beam of light thrown on the needle. Constant attention to so minute a detail puts a fearful strain on the eyes and nerves. In textile mills the number of machines has so increased that the operator is kept always at the highest rate of speed. In a large publishing house girls who bind the magazine must handle 25,000 copies, each weighing three fourths of a pound, in ten hours. Piece work aggravates the evil of keeping up with a machine. In the millinery trade "rush work" is of a similar character. This speed coupled with the monotony of doing the same operation repeatedly brings about nervous exhaustion. The monotony of the work exercises only little patches of the nervous system. Mental and physical fatigue are closely bound together. A muscle in contracting uses nitrogen and liberates a poison or toxin. Under normal conditions this toxin is carried out of the body by way of the kidneys and lungs, and is neutralized by an antitoxin. If the muscle is exercised too frequently the toxins multiply faster than the ability to eradicate them. The poison accumulates and the muscle becomes fatigued. Further work is performed at the expense of the will, which puts a drain on the nervous system. Fatigue may go to the point of exhaustion, and result in death by chemical self-poisoning. Normally the tired body throws off the toxins during sleep and is then ready for another full day's work. But if the body does not get rest, the fatigued muscles on the second day can do only one half the normal amount of work before again becoming fatigued. At the beginning the overwork may pass unnoticed, but since fatigue is accumulative it eventually results in a complete nervous breakdown, because fatigue really weakens the brain centers that control the muscles, although the feeling of being tired is primarily felt in the muscles themselves. Women are predisposed to nervous trouble, and their nerves are weakened by the various sex functions. Nervous tension exaggerates any bad tendencies already present. The industrial woman works to the point of over-fatigue and then goes home to do housework, or seeks excitement in dances and shows, thus adding nerve strain to nerve strain. Sleeplessness and loss of appetite follow; succeeding days of work pile up fatigue until the brain cells and nerves collapse. A usual accompaniment of nerve exhaustion is menstrual irregularities and poverty of the blood. The constant vibration in a mill may help bring about organic troubles, particularly if the organs have been weakened by other causes. The

vibrations plus noise act on the nerves as a continual light tapping does on steel. Both steel and nerves disintegrate. One girl said that when her machine stopped at night she always felt like screaming, which proved that her nervous energy was being too greatly sapped by the day's work.

The effect of the strain of industry then is to add mental to physical fatigue, destroying the recuperative power of the body. Since the sexual organs and the nervous system both take the same food elements from the blood and are delicately adjusted to each other, the toll industry takes of the nerves is sooner or later reflected in organic maladjustments.

As with monotonous work, so with industrial diseases no direct result on the fecundity of women can be pointed out. The harm comes indirectly through a lowering of general vitality and nerve strain. Lead poisoning seems to attack women more readily than men. It is a most potent producer of abortion, for it is rare for a woman working in lead fumes to give birth to a healthy child at term. Often the poisoning results in sterility. At first, the odor of carbon bisulphide in a rubber factory makes girls excitable, but it is followed by headache and nervous lassitude, with a loathing for food. As with morphine and cocaine, the cause has the semblance of a cure, a feeling of normality only when drugged. This produces the vicious circle, of poisoning, lassitude and repoisoning. The excitement causes undue fatigue, while malnutrition culminates in poverty of the blood, general debility and organic disturbances. The eating of the hands by acids in pickling factories, bleacheries and soap works tortures the workers and exhausts the nerves. Dust dries the throat. The effort to cough produces asthma or an inflammation which is a good seeding ground for tuberculosis. A hot, damp workroom weakens the body by excessive perspiration, and renders it liable to rheumatism, bronchitis and tuberculosis. Lifting heavy weights or running foot-power machines so injure the sex organs as to induce sterility. This list might be lengthened, but enough has already been written to make the point.

Malnutrition plays a part in lessening the vitality of working women. When a mother has to prepare a breakfast for a family before hurrying away to a shop, that breakfast is to be commended for the speed of its preparation rather than for its adherence to principles of proper diet. Bread and butter, coffee or tea and greasy meat, with the addition of a pickle as a stimulant, is the usual bill of fare, varied but little in the three meals of the day. There is not enough of cooked food and vegetables are lacking. The mother's body is not sufficiently nourished to withstand the double tax of factory work and house work, and if a child comes, the mother is sometimes too impoverished physically to nourish it. A baby should be fed every two hours, but a fac-

tory mother sees her infant once in six or ten hours only. Drugs are given to children only two weeks old to keep them quiet while the mother is away from home. Interference with lactation is injurious to the mother and fatal to the baby. The survivors of this heroic treatment grow up never having had sufficient nourishment. When it comes their turn to go to work, they do so not equipped with full vigor to meet the increasing stress of such work, but in a weakened condition, and are susceptible to all the ills before mentioned. Lifelong malnutrition added to pelvic deformities acquired by work is a serious drawback to the motherhood of working women.

Because children are a handicap, in calling for time and attention that is needed for other work, they are unwelcome or impossible to certain groups of women workers. A woman reporter or school teacher can not afford to have the demands of a child interfere with the requirements of her work, so in some branches of industry it can not be stated whether the women engaged in it are physically incapacitated for bearing children, or whether they have none because they do not wish them. All the social and economic factors which are causing a world-wide decline in the birth-rate operate in the various groups of working women and complicate any general conclusions that might be drawn as to the injury done by the work itself.

A hundred and fifty years ago the man who ventured to predict that no women would be allowed to work in mines, bar rooms, buffing or polishing metals or as public messengers would have been laughed at in scorn, but we to-day look upon such occupations for women with horror. May not our children's children think of a time when women worked in factories as a barbarous age? Lawmakers may some day forbid such labor on the grounds of the injury to the future race. We may not have to wait for such laws, however. Working conditions are usually the worst in the smaller concerns. The country is tending toward large-scale production, therefore conditions are slowly improving. But with large-scale production machines are larger, work heavier, speed and number of machines greater, so much so that men must be employed to do the work formerly done by women. The task a woman performs is largely of a mechanical nature, hence with large-scale production unreliable labor is replaced by a reliable automatic machine. The development of the loom from hand power to power driven, and from female to male attendance, and to final automatic action is an illustration in point. The more efficient machine may drive the less efficient woman out of the shop. In stores, offices and schools they must be more adequately protected by law, for it is evident that working, sooner or later, is reflected in fecundity.

THE FOURTH DIMENSION

By Professor SAMUEL M. BARTON
UNIVERSITY OF THE SOUTH, SEWANEE, TENN.

I. Non-Euclidean Geometry

As non-Euclidean geometry has not become popular enough to find a place in the ordinary college curriculum, and as its discovery preceded any serious consideration of space of more dimensions than three, it seems to me that, before taking up hyperspace proper, it would be well at least to mention the non-Euclidean geometries.

The mathematics of the college student is largely deductive, and he but faintly realizes the important part played by intuition, observation, induction and even imagination in the realms of higher mathematics. For instance, nothing surprises the layman—I use the word layman as including all who have not made some special study of higher mathematics—so much as to hear for the first time that the famous axiom of Euclid, namely: *If two lines are cut by a third, and the sum of the interior angles on the same side of the cutting line is less than two right angles, the lines will meet on that side when sufficiently produced,* is not necessarily true. And yet in very early times mathematicians began to doubt the truth of this axiom as it did not seem to be, like the rest, a simple elementary fact. The great geometer Legendre and other mathematicians attempted to give a proof of this so-called axiom, but without success. At last, to make a long story short, some mathematicians began to believe that this proposition was not only not self-evident, but was not capable of proof, and moreover that an equally consistent geometry could be built up on the supposition that it is not always true. Thus, out of various endeavors to prove Euclid's "parallel" axiom, arose non-Euclidean geometry, the beginning of which is sometimes attributed to Gauss; but as he did not publish anything on the subject, it is impossible to say what his ideas were. In the greatness of his heart, he generously gave full credit to Bolyai for his independent discoveries.

All honor, however, is due to two remarkable men, the Russian Lobatchevsky and the Hungarian Bolyai, who, about 1830, independently of each other, showed the denial of Euclid's parallel axiom led to a system of two-dimensional geometry as self-consistent as Euclid's. This new geometry is based on the assumption that through a given point a number of straight lines can be drawn parallel to a given straight line.

In 1854, the German Riemann[1] discovered another geometry. This geometry is based on the hypothesis that through a given point *no* straight line can be drawn parallel to a given straight line. Thus we have the three geometries: Euclid's (or the parabolic geometry), in which the "parallel axiom" holds, Lobatchevsky's (or the hyperbolic geometry), Riemann's (or the elliptic geometry). As is now well established, all three geometries are consistent with reality: Euclid's is true for a plane (a surface of zero curvature); Riemann's is true for a spherical surface (a two-dimensional space of constant positive curvature); Lobatchevsky's is true on the so-called pseudo-spherical surface of indefinite extent (a two-dimensional space of constant negative curvature). This pseudo-spherical surface is a saddle-shaped surface, like the inner surface of a solid ring.

It is to be noted that the straight line of one geometry is not the straight line of another, but in all three geometries it is the *shortest* distance between two points. Such straightest lines are "geodetic" lines. It will perhaps be evident now why in a sense the discovery of the non-Euclidean geometries was a stepping-stone to the consideration of hyperspace; though we should bear in mind that the two conceptions are entirely distinct, neither one being dependent upon the other. The logical conception of non-Euclidean geometry is far more difficult than the abstract notion of the fourth dimension. The study of the results arrived at by Lobatchevsky, Bolyai, Riemann, Beltrami and others forced men to think of "spaces," and it is hardly too much to say that the stimulus thus given to "high thinking" of this nature gave rise to the hypothetical acceptance of a fourth (or any higher) dimensional space.[2]

II. The Fourth Dimension

I come now to the consideration of hyperspace, which is space of any dimension above three, but for convenience and simplicity I shall confine myself mainly to fourth dimensional space.

To get any clear notion of the fourth dimension, one must make up his mind to exercise much patience, perhaps reading and re-reading many times articles by various authors. In this exposition of the subject, I would warn the reader against supposing that any attempt is here made to convince him of the possibility of the existence of fourth dimensional space. He is not even asked to *believe in* a material space

[1] Riemann, "Ueber die Hypothesen welche der Geometrie zu Grunde liegen," first read in 1854.

[2] Lobatschevsky's "The Theory of Parallels" and Bolyai's "The Science Absolute of Space" were translated into English by George Bruce Halsted and first appeared in *Scientiæ Baccalaureus*, a journal published for a short time by the Missouri School of Mines. By this and other publications Professor Halsted did much to popularize non-Euclidean geometry. Perhaps the most available short treatise on the subject in America is Professor Henry P. Manning's "Non-Euclidean Geometry."

other than our common, every day three-space. Fortunately a comparison with lower dimensional geometries furnishes so many analogies that the subject can be very fully explained in a non-mathematical way. Only let me say just here that the geometry of the fourth dimension is a perfectly logical system of theorems and proofs entirely independent of these analogies.

We, the dwellers in 3-space, can best realize the reasonableness of *conceiving* of a fourth or higher dimensional space by considering as best we may what would take place in lower-dimensional space did such exist.

Consider a pipe of indefinite length with a bore of diameter as small as you please, and suppose that there dwell within this pipe "worms" of such diameter that they just fill the pipe. We can not conceive of anything with no breadth or thickness, but let us consider for sake of the illustration that this one-dimensional animal (which for brevity I shall call a *unodim*) has only length. Of course these unodims may vary in length according to age or family traits, perhaps. Now it is evident that a unodim can never turn around. He may move forward or backward, but one unodim can never pass another. If he possesses an eye in front or behind he can see a neighboring unodim as a mere point. His world is a very limited one.

Again, we might imagine a two-dimensional animal, taking hold

FIG. 1.

of a *unodim,* turning him around in his (two-dimensional) space and putting him back with his "tail" where his "head" was before. Evidently the *unodim* would be ignorant of the cause of his reversion, for he has no knowledge of a two-dimensional space, and the two-dimensional animal is invisible to him. In other words, if AB and $A'B'$ in the figure are equal in length but running in opposite directions, it is impossible to put $A'B'$ in the place of AB, that is, A' where A is and B' where B is. To accomplish this, it would be necessary to take $A'B'$ into 2-space and turn it around. While this would be an impossible feat for a unodim, a two-space animal could readily do it.

FIG. 2.

Now this one-dimensional space may not be "straight" (that is, of zero curvature); but it may be the space that we should get by bending the pipe around in the form of a circle, as in Fig. 2. In such a case, as his body would be constantly bent in the same direction and by the same degree, we may suppose that the unodim is totally unconscious of

any curvature. It is well to note that in an exactly similar way our space may be curved without our being conscious of it. So he might feel just as certain that his space is "straight-line" space as we, the high and mighty 3-space beings, do that our space is Euclidean (or space of zero curvature).

Again, suppose the tube to be bent in an egg-shaped curve where the curvature is not constant. Here the unodim's world would still be one-dimensional, but as his body would be bent a little more in one part of his world than in another, it is possible that he may feel that there is some variety in his space. He may walk a little straighter at times and less straight at others. Whether his 1-space is straight or curved, and, if curved, whatever may be the variety of its convolutions, the unodim can not know of the existence of a world of 2-space or 3-space.

If a 2-space body, say a square, passes through his 1-space world, he sees only the 1-space section of the square.

In Fig. 3, *xy*, the 1-space world, is represented as being in the same

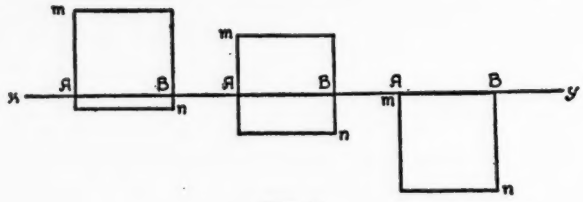


FIG. 3.

plane with the square *mn*. The square may cut *xy* at right angles or obliquely. In any case the *unodim* sees at any moment only the part of the square common to his world and is not conscious that there is any more to the square.

Two-space

Next let us consider 2-space.

Assume a 2-space being, which we shall call a *duodim*, that is, a *flat* being (theoretically with no thickness) with length and breadth and confined to a surface having length and breadth but no thickness. Such a being could move to the right or left or forward or backward, we will say, but neither up nor down from the surface. In fact, he knows neither *up* nor *down*: the surface is his world.

His position in his world is easily located by the Cartesian system of coordinates, that is, with reference to its distance from, say, two straight lines at right angles to each other. For illustration, define his world as the geometrical plane formed by the two lines *xx'*, *yy'* intersecting each other at right angles. Employing the usual notation, we consider distances measured perpendicular to the *Y*-axis as positive if measured to the right, and negative if to the left of the *Y*-axis. Such a distance is called the *abscissa* of the given point. Similarly, distances

measured perpendicular to the X-axis are positive if measured above and negative if below the X-axis, such a distance being called the *ordinate* of the given point.

Thus it is evident that a point is fully determined in the plane if its *abscissa* and *ordinate* are given. Every school boy has met with this principle in the location of a place on the earth's surface by latitude and longitude, where the axes of reference are great circles of the globe.

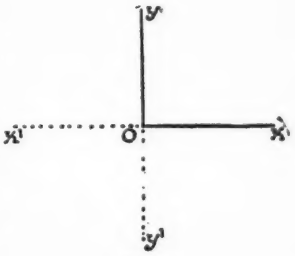


FIG. 4.

Now our *duodim* has a far more extended space than the *unodim*, and can do many things that the unodim is totally ignorant of. His space may not necessarily be one of zero curvature,—for it is perfectly consistent with our definition of 2-space for it to be the surface of a sphere, of an ellipsoid, of an egg-shaped figure, or what not. It is to be noticed that if the space has constant curvature (including no curvature), a body may be moved from any place to any other place on the surface *without changing its shape.*

If there are (Fig. 5) two triangles like E and F in which the sides

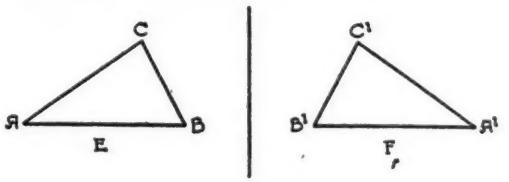


FIG. 5.

are equal each to each, but are arranged in reversed order, it is impossible in 2-space for F to be made to take the position of E. Here E is the reflection of F in a mirror. An inhabitant of 3-space has no difficulty, however, in taking up F, turning it over and putting it on the position E.

A three-dimensional body as such is of course invisible to a 2-space being. If a 3-space body, say a cube, crosses a 2-space, the 2-space being is conscious only of its section with his world.

Fig. 6 represents the effect of a 3-space body, a cube, passing through the 2-space pictured by the plane "*mn*." The section *ABCD* of the plane *mn* with the cube G is all that a *duodim* would be conscious of. As G passes through *mn*, this section, certainly if G is a homogeneous body, will appear the same until suddenly it vanishes as G passes beyond *mn*.

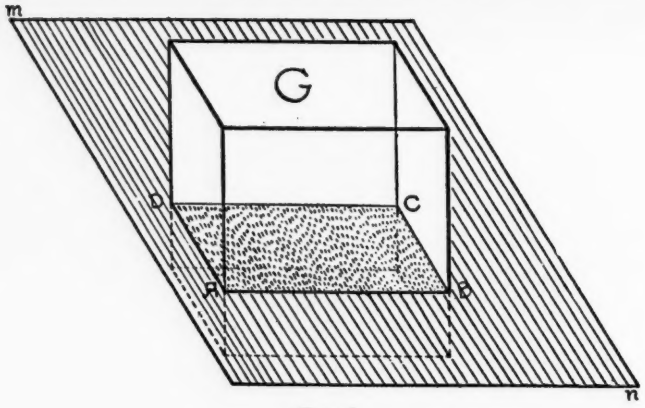


FIG. 6.

Three-space

Let us next direct our attention to 3-space, an inhabitant of which we might call an animal, but which, to continue the nomenclature adopted, we shall sometimes in a general way speak of as a *tridim.* Here freedom of life is much more augmented, even more so than in passing from 1-space to 2-space. For here we have added the up-and-down motion to the right-and-left and the forward-and-backward motions. Here any point is located by means of its distances from three mutually perpendicular planes, each plane being formed by two of the three lines that can be drawn mutually perpendicular to one another. In Fig. 7, *Ox, Oy, Oz*—representing directions to the right, hitherward and upward, respectively—are the axes of reference, each being perpendicular to the other two, forming the mutually perpendicular planes, *xOy, yOz, zOx.*

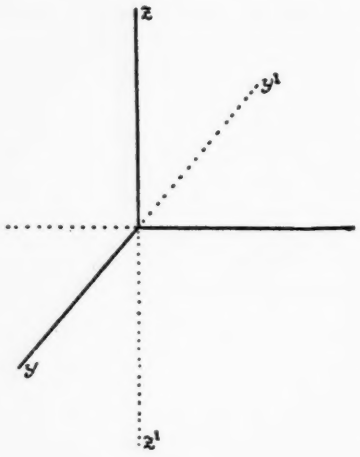


FIG. 7.

We saw that in 2-space the axes *xx'*, *yy'* divided the space into four equal parts of indefinite extent. A straight line in 2-space divides that space into two parts. In 3-space, it is evident that the coordinate planes divide space into eight equal parts of indefinite extent. Any point in 3-space is definitely determined when its distances from the three planes of reference is known. Distances perpendicular to the *yz* plane, denoted by *x*, are positive if measured to the right, *negative* if measured to the *left;* distances perpendicular to the *xz* plane, denoted by *y*, are *positive* if measured *towards* us, *negative* if measured *away from* us;

distances perpendicular to the *xy* plane are *positive* if measured *above*, *negative* if measured *below*. This notation enables us to locate any point in our space.

Now we know of 2-space only as a section of 3-space, and a *duodim* is purely an imaginary being to us; and we know of 1-space only as a section of 2-space (and therefore of 3-space), and the *unodim* is imaginary. We have seen that a duodim might interfere with life in 1-space, but the unodim would not know at all what had caused the

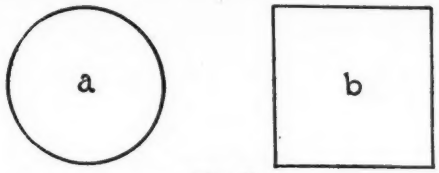


FIG. 8.

interference. We have also seen that a tridim might in a similar way interfere with life in 2-space. The important point to observe is that in either case the inhabitant of the lower space would not understand what had caused the change.

A duodim could lock up his treasure in circular or polygonal vaults, such as "*a*" or "*b*," safe from 2-space intruders, but a tridim could help himself to anything he pleased without breaking the sides of the vault. By analogy, a 4-space being could do many things in 3-space impossible to man and entirely inexplicable to him. No 3-space safe or vault would be secure from a 4-space burglar. He could get a ball out of a hollow shell without breaking the surface, he could get out the

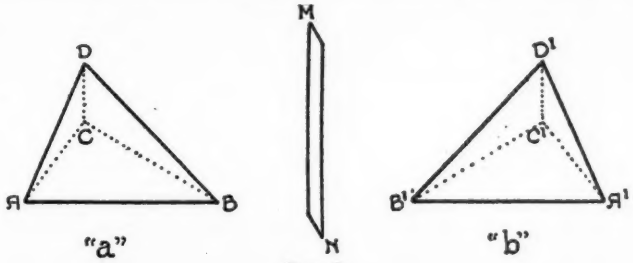


FIG. 9.

contents of an egg without cracking the shell and enjoy the kernel of a nut without the use of a nut-cracker.

A geometrical illustration similar to those already given is found in Fig. 9. Here "*a*" and "*b*" are symmetrical tetrahedrons,[3] in length

[3] A model of "*a*" and "*b*" can be readily constructed as follows: Cut out the figure (Fig. 10) from a piece of cardboard, perforated along the lines *AB*, *BC*, *CA*, and having $AF = AE$, $CE = CD$ and $BD = BF$. Fold over the triangle *ABF*, *ACE*, *CBD* till the points *F*, *E* and *D* meet in a point, thus making one tetrahedron: fold the triangles in the opposite direction and the symmetrical tetrahedron will be formed. The one corresponds to the image of the other in a mirror.

$AB = A'B'$, $AC = A'C'$, $BC = B'C'$, $AD = A'D'$, $BD = B'D'$, $CD = C'D'$. It is evidently impossible in 3-space to put "*b*" in the position "*a*," or *vice versa*. It would be possible to make "*b*" coincide with the image of "*a*" in a mirror. In fact it is obvious that "*b*" is the image of "*a*" as seen in a mirror.

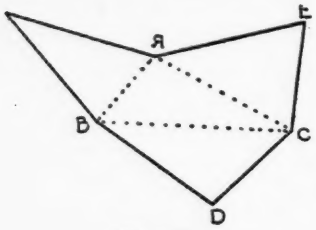


FIG. 10.

Readers of that classic nonsense book by Lewis Carroll (Rev. C. L. Dodgson), "Alice Behind the Looking-Glass," will be interested in the fact that Mr. Dodgson, himself a mathematician of no mean note, is poking fun at the fourth-dimension students.

Now, while it is impossible for a tridim to make "*b*" take the position "*a*," there would be no difficulty in a fourth-dimensional animal interchanging "*a*" and "*b*." In other words, to make "*a*" and "*b*" coincide, one must be taken up into 4-space, turned over and put down on the other.

It is easy now to see that, while there is no proof of the material existence of 4-space or space of any dimension higher than three, and while we can not even say that there is any likelihood that such exists, yet the *conception* of hyperspace is a perfectly real and logical conception; moreover, it is by no means an idle question or a useless idea. Assuming hyperspace, mathematicians have built up a perfectly consistent geometry which throws much light upon problems of 3-space.

We have seen that by many analogies it is a simple matter to *conceive* of hyperspace. Let us next observe how algebra invites us to consider the possible existence of higher space.

The solution of two simultaneous equations in two variables x, y, gives us a point in a plane. The solution of three simultaneous equations in three variables x, y, z, gives us a point in 3-space. The solution of four simultaneous equations in four variables, x, y, z, w, which is easily performed, gives what? Is there a geometrical equivalent here? Can the values of x, y, z, w be represented graphically? The answer to both questions is *No*, at least not in our space. Four-space is necessary if we are to give a geometrical representation to the solution of four simultaneous equations, such as:

$$\begin{aligned} a_1x + b_1y + c_1z + d_1w &= e_1, \\ a_2x + b_2y + c_2z + d_2w &= e_2, \\ a_3x + b_3y + c_3z + d_3w &= e_3, \\ a_4x + b_4y + c_4z + d_4w &= e_4, \end{aligned}$$

Again,

$$x = a$$

represent a point in 1-space. [Incidentally it would also denote a line in 2-space and a plane in 3-space.]

The equation

$$ax + by = c$$

represents a line in 2-space, but has no meaning in 1-space.

The equation

$$ax + by + cz = d$$

represents a plane in 3-space, but has no meaning in 2-space or 1-space.

So, by analogy, the equation

$$ax + by + cz + dw = e$$

would have a meaning in 4-space,—say a 3-space section of 4-space—but has no meaning in 3-space.

In general, an algebraic equation of k variables has no meaning in a space of lower dimension than k, but has a meaning in n-space, where $n \geqq k$.

Discarding experience and reasoning wholly from analogy, we introduce some properties of the fourth dimension as follows.

Four-dimensional measure depends upon length, breadth, height and a fourth dimension all multiplied together. In the graphical representation of 3-space, points are referred to three mutually perpendicular planes formed by three lines mutually at right angles. In a similar way, to represent 4-space we must assume another axis at right angles to each of the other three. In the present development of human thought, this is purely subjective, a mere mental conception, and it is upon this conception that the theory of hyperspace is built.

The position of a point in a plane may be determined, as we have seen, by its distance from each of two perpendicular right lines; in 3-space, by its distance from each of three mutually perpendicular planes; and in 4-space, by its distance from each of four mutually perpendicular 3-spaces, for there are four arrangements of the four axes taken *three* at a time, and each independent set of three perpendicular axes define a 3-space, for example, *wxy, wxz, wyz, xyz.* Just as in our space it requires at least three points to determine a plane (2-space), so in 4-space four points are necessary to determine a 3-space.

As portions of our space are bounded by surfaces, plane or curved, so portions of 4-space are bounded by hyperspace (three-dimensional).

In our space, a point moving in an unchanging direction generates a straight line.

This straight line (say of a units in length), moving perpendicular to its initial position through the distance a, generates a square.

This square, moving perpendicular to its initial position through the distance a, generates a cube.

This cube, we will suppose, moving perpendicular to our space for a distance equal to one of its sides (that is, equal to a), will generate a hypercube.

Now the line contains a units, the square a^2 units, the cube a^3 units, the hypercube a^4 units.

Again, to repeat in words slightly different from the foregoing (Fig. 11) considering the a units as a points (an indefinite number), the square *ABCD* is derived from the line *AB*, which for convenience suppose to be one foot in length, by letting *AB* with its a points move through a distance of one foot in a direction perpendicular to itself, that is, perpendicular to the one dimension of *AB*, every point of *AB* describes a line, and *ABCD* contains therefore a lines and a^2 points.

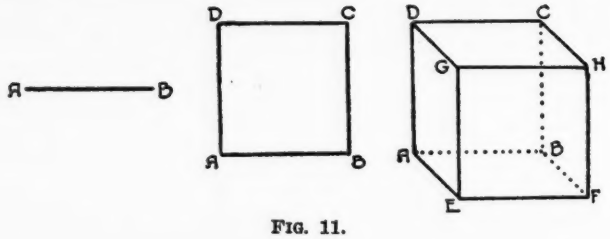


FIG. 11.

The cube *ABCD–G* is derived from the square *ABCD* which moves one foot in a direction perpendicular to its two dimensions, its a lines and a^2 points describing a squares and a^2 lines respectively. The cube *ABCD–G* therefore contains a squares, a^2 lines and a^3 points.

Similarly, the four-dimensional unit is derived from the cube, *ABCD–G*, by letting that cube move one foot in a direction perpendicular to each of its three dimensions, that is, in the direction of the fourth dimension; its a squares, a^2 lines, and a^3 points describing respectively a cubes, a^2 squares, a^3 lines. The hypercube, therefore, contains a cubes, a^2 squares, a^3 lines and a^4 points.

Boundaries

Now, as to the boundaries of the units, *AB* has two bounding points, *ABCD* has four, two each from the initial and the final position of the moving line, *ABCD–G* has eight,—four each from the initial and the final position of the moving square,—and the hypercube[4] has sixteen,—eight each from the initial and the final position of the moving cube.

Bounding Lines.—Of bounding *lines*, *AB* has one (or is itself one), *ABCD* has 4, one each from the initial and the final position of the moving line and 2 generated by the 2 bounding points of that line; *ABCD–G* has 12,—4 each from the initial and the final position of the moving square and 4 generated by the 4 bounding points of that square; and the hypercube has 32,—12 each from the initial and the final position of the moving cube and 8 generated by the 8 bounding points of that cube.

Bounding Squares.—Of bounding *squares*, *ABCD* has one (itself); *ABCD–G* has 6,—one each from the initial and the final position of

[4] This four-dimension unit is often called the "tesseract."

ABCD, and 4 described by the bounding lines of the moving square; and the hypercube has 24,—6 each from the initial and the final position of the moving cube, and 12 described by the bounding lines of the moving cube.

Bounding Cubes.—Finally, of bounding *cubes, ABCD–G* has one (itself); and the hypercube has 8,—one each from the initial and the final position of the moving cube, and 6 described by the bounding squares of the moving cube.

The results obtained for the boundaries may be conveniently exhibited by the following table:

BOUNDARIES

	Points	Lines	Squares	Cubes
One-dimensional unit.....	2	1	0	0
Two-dimensional unit.....	4	4	1	0
Three-dimensional unit.....	8	12	6	1
Four-dimensional unit.....	16	32	24	8

Freedom of movement is greater in hyperspace than in our space. The degrees of freedom of a rigid body in our space are 6, namely, 3 translations along and 3 rotations about 3 axes, while the fixing of 3 of its points, not in a straight line, prevents all movement. In hyperspace, however, with 3 of its points fixed, it could still rotate about the plane of those 3 points. A rigid body has 10 possible different movements in hyperspace, namely, 4 translations along 4 axes, and 6 rotations about 6 planes, while at least 4 of its points must be fixed to prevent all movement.

In hyperspace, a sphere of flexible material could without stretching or tearing be turned inside out. Two links of a chain could be separated without breaking them. Our knots would be useless. In hyperspace, as we have seen, it would be entirely possible to pass in and out of a sphere

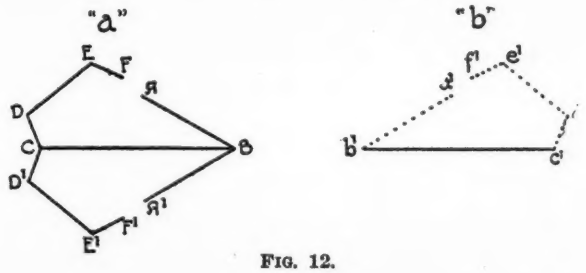


FIG. 12.

(or other enclosed space). A right glove turned over through space of four dimensions becomes a left glove, but notice that when the glove is *turned over,* it is *not turned inside out.*[5] This may be made clear by analogy. Suppose we have in a plane (Fig. 12) a nearly closed polygon

[5] A right glove turned inside out in *our* space becomes a left glove.

ABCDEF. This can be turned into its symmetrical form *A' BCD' E' F'*, the lower half of (*a*), by opening it out straight and bending it over the other way so that it is turned inside out. This process takes place entirely in the plane and can be performed by a two-dimensional being. The polygon may also be changed into its symmetrical form (*b*), Fig. 12, by being turned over, in 3-space, but in this process it is not turned inside out at all. On the other hand, if it is sufficiently flexible, it may be turned inside out by twisting each part upon itself through 180 degrees, and in this process it is not changed into its symmetrical form.

When mathematicians began to talk of higher space, the spiritualists seized upon the idea as affording a habitation for their spirits. These men, naturally wanting a home for their spirits, were rather too eager to believe in the actual existence of the fourth dimension. It is astonishing with what avidity the advocates of spirit rappings and occult demonstrations appropriated the fourth dimension for the abiding place of their unearthly beings. This was, of course, unwarranted as are perhaps most of the claims of such people. While somewhat interesting, it is too trivial to claim our serious attention.

In conclusion, we have no material evidence of a fourth dimension. Our knowledge of the phenomena of 3-space is empirical. Our experience tells us nothing of 4-space, if it exists. But the *conception*, not being dependent upon experience or experiment, is not unreasonable. As a working hypothesis it is not without decided value, as it throws light upon many propositions of our (3-space) geometry.

The existence of 4-space might explain certain phenomena in physics and chemistry; for instance, rotation in hyperspace would explain the changes of a body producing a right-handed polarization of light into one giving a left-handed.

A few months ago an article appeared in the *Scientific American* by E. L. DuPuy setting forth the use of four dimensions in representing certain chemical compounds graphically. He took as an example a "special steel" consisting of iron, carbon, silicon-manganese and nickel-vanadium.

In this short sketch of what is meant by the fourth dimension, it must be borne in mind that the mathematical investigation of the geometry of the fourth dimension has been omitted altogether. It is hardly necessary to add that all arguments for the existence of a fourth dimension apply equally well for the existence of 5, 6, or *n* dimensional space. The geometry of *n*-space, where *n* is any number, is just as logical as that of 4-space.

[In this paper the author claims no originality, except to some extent in the mode of presentation and in the manner of introducing the illustrations; but he has not knowingly made use of any ideas that

have not now become public property. The following are some of the works that he has consulted: "Non-Euclidean Geometry," by Henry P. Manning; "The Elements of Non-Euclidean Geometry," by L. L. Coolidge; "The Fourth Dimension Simply Explained—a collection of Popular Essays with an Introduction and Editorial Notes by the Editor," Henry P. Manning, editor (published by the *Scientific American*); "The Fourth Dimension," by C. H. Hinton; "The Fourth Dimension," in "Mathematical Essays and Recreations," by Hermann Schubert, translated by T. J. McCormack.]

SOME PSYCHOLOGICAL PROBLEMS EMPHASIZED BY PRAGMATISM

By Professor JOSIAH ROYCE
HARVARD UNIVERSITY

IT is not my purpose upon this occasion to enter into the philosophical aspect of the discussion regarding pragmatism, excepting in so far as may be necessary to call attention to the psychological problems that I now have in mind. I presuppose, of course, a familiarity on the part of all of you with the main outlines of the recent discussions concerning the problem of truth. But I shall not try with any exactness to define what the term pragmatism means. I recognize that the word as now used refers to a considerable variety of opinions, and that the comparison of a "holding company," which Professor Dewey has, I believe, on one occasion employed, is not altogether inapt. It is enough for our present purpose that by the name pragmatism we all of us mean a certain set of tendencies in recent discussion which lay stress upon the importance of defining the truth of propositions or judgments or ideas in terms of those empirical facts and relations of facts which are said to constitute the "workings" of the propositions, or judgments, or ideas which are in question. The favorite summary of pragmatism, to the effect that from the point of view of pragmatism a proposition, or judgment, or idea is true "if it works," is sufficient to serve as a general indication of the tendencies of opinion which are here in question.

What pragmatism asserts about truth may be considered from the point of view of a general theory of knowledge, or of a metaphysic. But pragmatism itself especially emphasizes its relation to psychology, on the one hand, and to the recognized methods of empirical science, on the other. As Mr. Schiller said to me during the Philosophical Congress of 1908 at Heidelberg, "What is most essential to pragmatism is that it insists that the relations and values of the thinking process must be estimated in psychological terms. Success tests truth, and success is itself a matter of experience that can best be understood when it is defined psychologically." Another way of stating the essence of pragmatism is to insist, as Professor Dewey has so often done, upon the fact that the method which pragmatism proposes to apply to all problems is the method already used by the various sciences of experience. They employ "working hypotheses." They test these working hypotheses by

comparison with experience. Pragmatism consists in the assertion that all propositions should be tested as the hypotheses of science are tested.

These two points of view are, of course, very closely connected. Students of the physical sciences often take little account of the psychology of their own processes. But the processes of science obviously have their psychology, and this psychology conforms in its types to those laws of mental activity which have interested psychologists ever since the apperceptive process was formulated by Herbart,—yes, ever since the doctrine of association was so widely applied by the English psychologists, and still more since the modern so-called "functional" psychology has connected the apperceptive processes and the associative linkages with the physical processes whereby an organism is adjusted to its environment. The psychology of the apperceptive process, and the work of the scientific finding and testing of hypotheses, have a close relation, and since common sense also is interested in successful verifications, although this interest is less precise than is the interest of the student of the more exact sciences of observation in the criteria to which they submit their more careful tests,—common sense and science and psychology join in contributing their various shares to the modern general theory of truth.

But now to come to the matter to which I wish especially to attract your attention. Since pragmatism is thus especially interested in the psychology of the thinking process, it has emphasized this psychological problem in recent literature. A general psychology of thought, on a pragmatic basis, has been worked out by Professor Pillsbury. The psychological text-books of the Chicago school, and in particular the contributions of Professor Dewey, have familiarized us with other accounts of the psychology of thought. The psychological problems to which attention is thus especially attracted may be, of course, studied apart from their relations to the theory of truth. These problems are threefold. (1) There are the problems regarding the processes whereby hypotheses are invented, or, in common-sense terms, the processes whereby people get their ideas; (2) there are problems regarding the processes whereby ideas, once in hand, are made sufficiently clear to be a proper subject for testing; and (3) a psychological problem arises as to what happens when an idea is tested. To all these problems the pragmatists as psychologists have contributed. I wish to illustrate in the course of my discussion a certain dissatisfaction which I feel with the present state of some of their contributions to these purely psychological issues, when viewed apart from the other issues of the pragmatist philosophy.

Yet I admit that when you hear me you will say that my psychological dissatisfactions are due to certain philosophical dissatisfactions, and that the pragmatist psychology appears to me inadequate partly

because I do not wholly accept the pragmatist theory of truth. I recognize the connection in my own mind between the two dissatisfactions. I do not wish to pretend that I can wholly dissociate my interest in psychology from my interest in the other aspects of the pragmatist controversy and in the very nature of pragmatism itself. My pragmatist friends least of all would desire me to do this. And so I shall aid you in following my further inquiries if I first briefly state one ground of my dissatisfaction as a student of logic and of general philosophy, with the pragamtist's theory of truth. This statement I make not as if it were here important for the psychological purpose of this discussion, but because by confessing my own state of mind I may help you to fix your attention upon matters that will more directly interest you. For my dissatisfaction as a student of logic, with the pragmatist theory regarding truth, will call attention to the way in which I should approach precisely those psychological problems which pragmatism has most emphasized.

I

When pragmatism asserts that the truth of a proposition is tested by the "workings" of the ideas that the proposition expresses, a student of logic very naturally raises the question as to *what* workings are meant. A man who hears a proposition and who more or less completely understands its meaning, and who hereupon more or less believes the proposition, has certain mental attitudes aroused in him, and these mental attitudes have their physical expression. They tend to lead to action. The action may well be accompained by expectations of various sorts, and the expectations may remain throughout more or less identical with those that the utterance of the proposition first arouses in the mind of the inquirer. Thus ideas may lead to actions. These actions may gratify or in a measure satisfy expectations. In this case the ideas which the proposition expressed are said to "work." But now consider the contrast between what this decidedly general statement expresses and what a student of any more exact empirical science is likely to have in mind when he thinks of testing the truth of a definite assertion. One familiar process of testing the truth of hypotheses in scientific regions is to trace the consequences that must be true if those hypotheses are true, and then to see whether these consequences can be found verified by particular experiences. An essential part of this process is the deduction of certain consequences from one's hypothesis. How extensive this deductive process may be, a glance at any textbook of theoretical physics, in particular of theoretical astronomy of the classic type, will show.

Now what happens when one deduces the consequences of an hypothesis? Does one simply let one's ideas work? Are the consequences of hypotheses simply ideas that are as a fact aroused in the mind of a

man who begins with the hypothesis itself in mind? Certainly the usual taste and purpose of the student of any more exact science is *not* sufficiently expressed by saying that he looks merely for such "workings" as may happen to be suggested to his mind. *He is looking for what must be true if the hypothesis is true.* He is making use of those mental processes whose nature is sometimes discussed in text-books of deductive logic. But when we are dealing merely with the world of common sense, ideas that have been suggested or propositions that have been uttered, frequently arouse in our minds expectations which are not directly called for by the logical meaning of the propositions, but which through various processes of association or various reminders of past experience are more or less casually aroused. Such resulting expectations may be said in a given mind to follow from the utterance of the proposition that arouses them. But they are not logical consequences of the proposition in the sense which the student of the more exact sciences has in mind.

Again, when the student of an exact science has made his deductions and proceeds to verify them, he may find his hypothesis confirmed or refuted by the results of experience. In this case his hypothesis may be said to "work," but what sort of working is in question in the more exact sciences? I answer, in any more exact science the confirmations or refutations which experience is able to furnish to the hypothesis whose logical consequences are to be tested, are required to be so exact that we can define them in definite *affirmations* and *denials.* The very essence of precise confirmation or refutation is that if it is as successful as the requirements of an exact science demand, we are able to say as the result of our process of confirmation, "So and so, thus and thus defined, happens or does not happen, is found or is not found." Or again, we sometimes say of the failing hypothesis, "It is *contradicted* by the facts." Somewhat different however is the situation in the world of common sense, where one's expectation may often be met or disappointed with very various degrees of definiteness. In the world of common sense a man may say, "This more or less meets my expectations." In the world of an exact science the investigator is interested in seeing within what precise limits a definite experienced measurement agrees with the prediction. *Precision,* in other words, characterizes the confirmations or refutations which experience furnishes in the more advanced sciences. And the concept of precision has characters which are studied in text-books of logic, although, as I admit, in most text-books of logic the concept of precision is very inadequately studied.

In consequence of all this the student of logic is likely to object to the ordinary formulation of pragmatism, (1) that pragmatism seems not to be interested in the distinction between merely arousing an expectation, and deducing a consequence; (2) that it takes compara-

tively little account of the distinction between feeling more or less personal satisfaction in partial agreements between experience and our expectations, and precisely confirming or refuting a determinate hypothesis, in so far as that can be done by a certain group of experiences.

And finally the student of logic finds a certain difficulty in the usual statements of pragmatism regarding the sense in which empirical verifications are said to lead to a certain "belief" that the ideas which we have been trying to verify are true. In ordinary life beliefs exist in all sorts of vague degrees of intensity. But when the student of a science formulates his results, considerable stress is laid upon the assertion that, by virtue of a given group of confirmations, a hypothesis has received a somewhat determinate degree of what is called *objective probability*. Now into the theory of probability this is no place to go. But most of you who have dealt with statistical probabilities will admit that our subjective confidence is somewhat different in its nature from that objective or statistically estimated probability which most students of an inductive science prefer to be able to define if they can. The whole modern development of the theory of probability has been in the direction of separating the concept of objective probability from the concept of subjective belief or confidence. From the objective point of view a proposition has a certain probability P in case it belongs to the class of propositions of which in the long run a proportion P are true. The difficulty of defining such probability with genuine exactness is great, and the whole subject of probability is too complex to be here discussed, but the student of logic feels dissatisfied with the fact that his pragmatist brethren take little interest in defining the difference between the vague confidence which in the world of common sense confirmed expectations may arouse, and the scientific measure of probability in exact and relatively objective terms which the students of an inductive science are commonly seeking.

II

So much for my general statement of logical scruples concerning the adequacy of pragmatistic formulations. Into the merits of these logical scruples I have no wish to go on this occasion. I have stated them merely in order to formulate the problems of a psychological nature to which I wish to attract attention. Pragmatism has emphasized these problems, has undertaken to solve them, has contributed a great deal to their study, but in my opinion has failed to satisfy all the requirements that it might satisfy, just because it is not sufficiently interested in the very logical problems that I have just outlined. These logical problems, however, have their psychological aspects. If one does not deal with them in an exact fashion from the logical point of view, one is not likely to have one's attention attracted to their psychological

complexity. On the other hand, if I can do anything to awaken your interest in the psychological character of these problems, perhaps I may indirectly help to awaken interest in their logical aspect.

Let me repeat the list of the problems to which I have called attention, emphasizing the sense in which each one of them is a psychological problem. I mention the fact that a science which is testing hypotheses *deduces the logical consequences of these hypotheses.* The process may be an extended one. *What is the psychology of deduction?* What happens when a process of deduction takes place? In some respects this problem has indeed been repeatedly dealt with from the psychological point of view. I do not wish in the least to deny that the analyses of Professor Pillsbury and others have contributed to this problem, but just because these psychologists have been so little interested in the logic of the deductive process they have failed, in my opinion, to emphasize some of its most important psychological aspects. Yet their own discussions emphasize the need of such a psychology. Here lies the first of the problems to which I now call attention.

Secondly, the pragmatists in speaking of the working hypothesis have emphasized, as Professor Moore has recently done, the fact that the agreement of an assertion or idea with its expected workings constitutes the test of its truth so far as up to a certain point in our investigations we may happen to have gone. I have called attention to the difference between an expectation and an assertion or a denial. One goes to the play expecting amusement. At the end of the play, have his expectations been met or not? The question may be unanswerable in any definite way. The play was amusing, and yet perhaps not so very amusing, or not so amusing as one could have wished it to be. One goes away partially disappointed, partially pleased. One is not so disappointed but that one continues to go to plays over and over again. One is not so pleased that he expresses himself very enthusiastically. What ideas with regard to the amusing character of plays have been precisely tested, so long as one remains in this state of mind? On the other hand, through a deductive process the occurrence of an eclipse is precisely predicted. The eclipse is observed, its beginning is noted with an accuracy as great as the errors of observation permit. A precise assertion is made as to the agreement between the prediction and the observation. When the assertion has received its proper qualifications with regard to probable error and the rest, the assertion appears in the records as true or false. In this case an issue is met and something is tested, yes or no. I now ask, what is the psychology of assertion and denial, of the difference between yes and no? In what way does this difference, namely that between yes and no, differ from any other kind of difference? This problem I mention, without hoping in this paper to do more than mention it. I called attention to this psycho-

logical problem some years since in an address that I was permitted to give before the Psychological Association. I venture to emphasize this problem afresh and to declare that it is a problem which the whole pragmatist controversy has itself especially emphasized and has not yet adequately solved.

Again I have called attention to the difference between vaguely estimated confidence and objective probability. Here is a problem that once more presents psychological aspects. I shall have no time to discuss them upon this occasion. The psychology of probability is, however, to my mind one full of very interesting problems.

III

I have thus enumerated three of the psychological problems which to my mind are emphasized by the course of the pragmatistic discussion. That these problems come to my mind with a special force because of my logical interest, you see. It is now my purpose to appeal to you as psychologists or as students interested in the subject, to follow for a few moments some further characterization especially of the first of these psychological problems. I am dissatisfied in the recent discussions of the psychology of reasoning with what seems to be a failure to understand what takes place in exact deductive procedure. The current prejudices as well as the hoary traditions on this subject seem to conspire to call the attention of students away from the center of the problem. Without attempting to give any adequate summary of Professor Pillsbury's account of the reasoning process in his recent "Psychology of Reasoning," I may attempt by a few references to indicate how inadequate some current views are to take account of what the deductive process actually is. In Professor Pillsbury's "Psychology of Reasoning," he distinguishes pretty sharply between the two processes of *inference* and *proof*. By inference, if I understand him, he means the process whereby a conclusion is suggested in such wise as to arouse more or less belief. By proof he means a process whereby this belief is more or less adequately tested. Now logicians are accustomed to use the word inference in a somewhat different way from that which Professor Pillsbury emphasizes. And what this way is I shall try to point out in a moment. But laying inference aside for the moment, and passing to the other side of the reasoning process as Professor Pillsbury defines it, namely to the process of proof, the only form of deductive proof which Professor Pillsbury seems to emphasize is the one that has received its traditional description in the doctrine of the syllogism. The essence of the traditional syllogism is, according to Professor Pillsbury, that the general major premise is supposed to aid us in testing our belief in the conclusion, by virtue of the fact that in the minor premise something

has been brought under this major premise as a particular case of the principle. Professor Pillsbury consequently points out how comparatively insignificant both from the logical and from the psychological point of view the syllogism is as an expression of the nature of the concrete process of reasoning. To bring cases under major premises is to do little to confirm our belief except in so far as one thus emphasizes in a somewhat formal way the tendency of every new or questionable fact to find its place by being brought into conformity with the habits, or better with the principles of action, which have been formulated on the basis of previous experience. Deductive proof appears therefore to be, as Professor Pillsbury says, not so different from induction as is usually supposed, and to be in any case of comparatively minor importance. The business of proof, according to Professor Pillsbury, is to produce belief. Belief in general is not produced by formulating major premises. It is produced by a more complex process whose general nature he sets forth.

Other familiar discussions of the reasoning process, such as one finds in the text-books of recent pragmatists, agree with Professor Pillsbury in assuming that it is of the essence of deduction or of deductive proof to proceed from the general to the particular, and that the significance of deductive proof lies in the fact that one hereby formulates, often somewhat uselessly, the general process by which an adjustment to the environment in cases of initial doubt or difficulty is attained. Apart from these statements more characteristic of pragmatists, a wide-spread tradition, which unfortunately is supported by the older logical text-books themselves, maintains that it is of the essence of deductive reasoning to bring nothing out of the premises except what was already in them, so that the essence of the deduction is "analysis." From this point of view it is supposed that when you engage in deduction you solemnly draw out of the bag the cat which you have already hidden in it. You declare, for instance, that all the *A*'s that are *B* are indeed *B*, and solemnly demonstrate that all the white mice must be both white and mice. It is unquestionable that many of the logicians of the past as well as the psychologists of recent times have conspired to give this impression of the deductive process. But whatever the psychology of deduction may be, any fair examination of the work of the exact deductive operations of science, and especially any examination of the work of mathematics, shows that deduction as it exists in real life is simply not this fiction of the older logical text-books. And yet to the psychological analysis of this fiction, with the natural result that such a process is not of very great importance, Professor Pillsbury, as I understand him, devotes himself in his discussion of the place of the syllogism in life.

But anybody who undertakes to deal with the psychology of reason-

ing ought, I think, to take account of the fact that there is nowadays a new logic, that this new logic is in considerable part the work of men whose attention has been attracted to the nature of the deductive process by a wide experience of mathematical procedure, and that this new logic shows us with regard to the syllogism, for instance, two things, first that the essence of the syllogism does not consist in the fact that a particular case is brought under a general principle; and secondly, that the syllogism is by no means the only form of deductive reasoning. From the point of view of the new logic, the student has upon his hands the problem that Poincaré has so well stated at the outset of his book, "Science and Hypothesis." This is the problem presented by the enormous *Fecundity of the Deductive Process.* Our own American logician, Charles Peirce, long since called attention to this fecundity. It is a fact of much philosophical importance. What I mean by the fecundity of deduction as a logical fact can be suggested by what Poincaré mentioned, and also by a summary of the matters to which Peirce has frequently called attention. Poincaré states the case thus: From the point of view of the older interpretation of the nature of the syllogism it would seem impossible that a deductive science such as mathematics could do anything but draw out of premises what it had already more or less overtly or secretly put into them. Nothing novel could result. And in fact if the reasoning of mathematics were all of the kind that Professor Pillsbury supposes to be the typical deductive reasoning, mathematical science would consist in a process as stupid and monotonous as the process of taking the major premise, All men are mortal, and then looking up all the names in a directory and solemnly concluding to write opposite to each name the fact that since this person is a man he is mortal. But now as a fact mathematical science consists of nothing of the kind. The situation is actually this: you can write upon a few sheets of paper an accurate statement of a set of principles from which the whole science of the quantities of ordinary algebra can be deduced. That is to say, the principles of the ordinary mathematical analysis are capable of such a brief statement as this. But the consequences of these principles are such that novel results in vast numbers are annually discovered. These results are not stowed away in the premises in any such way as that in which the mortality of this man is stowed away in the assertion of the mortality of all men.

Poincaré, in the passage to which I have referred, suggests his own theory to account for the fecundity of mathematical analysis. His theory may as a logical theory be questioned. But the fecundity to which he attracts attention ought to be a commonplace to any one who has looked into any branch of mathematics with care. Peirce has called attention to this fact, and speaking as a logician has gone further. Following a lead of De Morgan's, Peirce has shown that any proposition

whatever which has a definite meaning permits you to draw from it an infinite number of deductive inferences, all of which are possible without formulating any other basis for the deductions in question than the assertion of the original proposition and the synthetic power which one indeed has in his hands who is capable of understanding certain simple processes of the construction of relations. Let me mention the instance, famous in modern logic, which De Morgan first formulated; and which as it stands may appear trivial enough. If a horse is an animal, you can deduce from that hypothesis the conclusion that the owner of a horse is the owner of an animal, that the friend of the owner of a horse is the friend of the owner of an animal, and so on. Such deductions in an individual case such as that of the assertion about a horse may seem and are trivial enough. *But they have the character of novelty:* That is, the conclusion does not follow from the premises by the process of first stuffing a vast number of cases into a bag and then pulling them out one by one. But the process of deduction thus illustrated can be used and is used as an instrument of enormous power in those branches of mathematics in which one builds one system of relations upon another system. The number of ways whereby such deductive processes can be accomplished is presumably very great. And it is because such processes are possible that mathematical reasoning possesses its great fecundity.

And now since such fecundity, such proof of novelties, is the essence of the live process of deduction as it exists in the deductive sciences, why should not psychologists study that live process instead of studying the dead body which some text-books have called the syllogism? And if they must study the syllogism as the supposed typical example of deductive reasoning, why should they confine their attention to considering the most traditional and trivial aspect of it?

As modern logic has shown, the really essential feature of the syllogism lies in the fact that what the logicians call the Illative Relation (that is, the relation which is in mind when you consider one proposition as true in case another is true) is a relation which has the property of so-called *transitivity.* That is, the essence of the syllogism may be stated by saying that from the pair of propositions "*A* implies *B*," and "*B* implies *C*" taken together you can deduce the conclusion "*A* implies *C*." In other words, it is of the nature of the illative relation that it permits the use of what James called the principle or axiom of skipped intermediaries. I can not pause to show why this account of the essence of the syllogism is logically correct. But the mere mention of this fact shows that those who analyze the process of deduction, supposing it to be represented by the traditional syllogism, and interpreting the traditional syllogism in the way in which Professor Pillsbury interprets it, simply miss the most interesting feature of syllogistic reasoning.

Nor is the aspect of the syllogistic reasoning which this emphasizes, the only one to which modern logic calls attention. Mrs. Ladd-Franklin long ago pointed out that the entire theory of the syllogism could be stated as a sort of comment upon the fact that a triad of propositions which she called "a triadic inconsistency" has, when considered as a triad, a certain set of logical properties. These logical properties, belonging to such a triad of propositions, can be observed by a process which is of the nature widely illustrated throughout the whole realm of mathematics; but this is certainly *not* the synthesis that Professor Pillsbury has in mind when he analyzes what he supposes to be a typical process of deductive reasoning.

Still more unfortunate for the study of the psychology of the reasoning process is that misunderstanding of the nature of deduction which supposes that the principal use of a deduction is to bring to pass a belief in a certain conclusion by virtue of an appeal to a belief in certain premises. This assumption, common in the recent literature of pragmatism, is false to the most essential use of deduction in the exact sciences. Mr. Russell has well emphasized the fact that, in mathematical science, just in so far as it is pure mathematics, you are not concerned with producing belief in the conclusions themselves. Your interest in pure mathematics, that is to say in that science which deals with deduction proper, lies simply in showing that *certain premises do imply certain conclusions.* That is, you show that "p implies q," where p and q are propositions. The importance of mathematics for the empirical sciences is due to the fact that it gives you a means for testing the hypotheses by first finding out what are their logical consequences. Now it is essential for the fair and unprejudiced testing of an hypothesis, that you should *not* be too much disposed to believe in it before you test it. It is very important, when you do not believe an hypothesis, or when your mind is still perfectly open upon the subject, *to find out with exactness what would be true if the hypothesis were true.* Your purpose in deduction is therefore not to establish belief in certain consequences by virtue of a previous belief in the hypothesis upon which they depend. Your great interest is to produce *no belief whatever either in the hypothesis or in the conclusions from the hypothesis, until the logical issues are precisely defined* for empirical confirmation; and then you are *ready* to appeal to the confirming or refuting experience. It is a strange misunderstanding of the nature of the deductive process to suppose that its principal interest is an interest in producing belief in consequences. The sole logical interest of the deductive inquirer lies in his discovery that certain premises imply certain conclusions.

To sum up, then, this sketch: I assert that in the recent psychology of reasoning, *the nature of the deductive process and its principal purpose have been equally misunderstood.* Deduction in its more developed

forms simply does *not* consist in an analysis of the premises. Nor is it intended to make you believe the conclusion. The true interest of deduction lies in the fact (1) that it is a process possessing an inexhaustible fecundity, and (2) that this fruitfulness results in giving you a knowledge that certain premises imply certain conclusions.

IV

But now let me briefly put before you some genuine deductive processes, and point out what problems with regard to their psychology can be aroused. Let me begin with the instance with which I have often wearied my friends, so that some of you who are here present will have heard me mention it. Raise the question whether a strip of paper can exist which shall have only one side. One would be disposed to settle the question empirically by observing that every strip of paper in one's ordinary experience obviously has two sides. If one passes from a consideration of strips of paper that have two ends, to the consideration of endless strips of paper, that is strips of paper made in ring shape, one sees that in an ordinary ring the two-sidedness of strips of paper still holds good. But if one takes an ordinary strip of paper, say two inches wide and eight or ten inches long, first twists one end of it 180 degrees, and then brings the two ends together, one has the resulting geometrical form of the one-sided ring. The first discovery that such a ring is possible was of course an empirical discovery. But the geometers (I believe it was Möbius who first noticed one-sided surfaces) had their attention at once attracted to the mathematically interesting properties of this form. Now when such a form is viewed as a mathematical object, any one with mathematical interest naturally proceeds to an undertaking of the sort which is characteristic of mathematical science in general. One endeavors to deduce some of these properties from others, or to discover, as the ordinary mind would say, why these properties belong to any one-sided surface. Hereupon let me mention a problem that can be studied as soon as you have once taken note of the one-sided surface and have begun to make a study of the real sense or connection of its structure. Suppose a one-sided surface, a ring strip of the sort that I have described, to be cut down the middle, midway between what appear to be the two edges of the strip, and suppose the cut continued until it returns into itself, what will be the result? There are two ways of answering the question. One is the directly empirical one of making the cut. The other method is to endeavor to see before making the strip what must be the result in view of the one-sidedness of the strip. I once proposed the question to a class, and found a member of the class, who although not a student of mathematics, possessed a relatively clear visual imagination, was ingenious, became interested in the problem, solved it without cutting the strip, then tested

his solution by an actual cut, and then brought me written out the process of reasoning whereby he had solved the problem.

The process of reasoning in question, or any process of reasoning by which the problem could be solved in advance of actually cutting the strip, is in part a genuine instance of deductive reasoning. Just because of the intimate mingling of empirical data and of exactly definable relationships, the case in question forms an admirable instance of the study of the genuine psychology of the deductive process; but I confess that no psychologist would make much of the study who was not fairly well acquainted with deductive processes of a certain complexity, —processes which in their more exact forms you will find anywhere in pure mathematics, where a symbolic language with an exact definition is used, as the only means of presenting data to the imagination.

Let me mention another instance of a deductive process of some complexity, but of great ingenuity and of interesting psychological relationships. We know that about 500 B. C. a member of the Pythagorean school discovered that granting the ordinary principles of metrical geometry as they were then and ever since have been used, the diagonal of a square could not be commensurate with the side of the square. The strictly deductive portion of this proof can be with fair ease distinguished from that portion of the proof in question which is indeed empirical and not deductive. That figures resembling squares exist is a matter of experience. That if you make a square exactly enough and large enough, and measure carefully enough you will discover that by no rule you seem to be certain of stating the ratio of diagonal to side exactly in terms of whole numbers: this again is so far empirical. And the ordinary so-called axioms of metrical geometry, considered as principles about the constitution of the physical world, are of course generalizations from physical experience. On the other hand, the purely mathematical portion of geometry, that is, the purely deductive portion, consists in the discovery, not that the geometrical axioms are self-evident or otherwise certain, and not that the physical world has any properties whatever, but that certain assumed geometrical principles which can be stated wholly in symbols, actually imply certain geometrical conclusions. Now the early Greek geometer who discovered that the diagonal and the side of the square are from the point of view of geometrical theory incommensurable, was no doubt guided by the empirical difficulty of discovering any rule whereby a common measure for the diagonal and the side could be stated. Furthermore, he was not clear in his own mind as to the precise distinction between the deductive and the inductive part of his geometrical science. But he was possessed of the power to draw an exact deductive conclusion. And what he found out was that if certain principles of measurement and certain purely mathematical properties of whole numbers be admitted, the diagonal and

side of the square are incommensurable. That is, he discovered that certain premises imply certain conclusions.

The process by which he discovered this we happen, though somewhat indirectly, to know. The instance is a remarkable one of the fecundity of the deductive process. The conclusion when the Greek reached it was a novelty. It seemed to him so novel and uncanny a conclusion that the Pythagorean school is said by a later tradition to have long regarded the whole matter as a mystery which must not be mentioned to the vulgar. It was reported that the man who revealed this mystery came to a bad end and received special penalties in the underworld, so closely in those days was exact science linked with *tabu* and with superstition. Yet no one who once goes through the little process of reasoning by which the ancient geometer established his result can remain without interest in the psychology of such a process.

V

You see throughout how my account of the whole matter is of course colored by my logical interests, and yet I freely admit that the psychological problems at issue ought to be considered without any undue reference to anybody's philosophical prejudices or concerns. I admit my own bias in the matter, merely because I am thereby enabled to call attention to what the live process of deduction is, and to point out that the recent psychology of reasoning has profoundly neglected to take account of some of the most elementary facts with regard to the nature of this process.

Charles Peirce long ago called attention to the general nature of the psychological processes which are in question in deduction. They are processes of the nature of ideal experiments. The instance of the one-sided strip of paper readily shows how many intermediate steps there may be between such ideal experiments and physical experiments with a strip of paper. On the other hand, as soon as you begin to reason, and to predict what will be true about a given strip of paper if certain hypotheses are met, with regard to its structure, you get an insight into the whole situation which you can not possibly get by cutting the strip of paper without adding the deductive process. And in general, wherever deduction is worth while, the testing of hypotheses after deductions have carefully been made whereby we predict determinate results of such hypotheses, has a wholly different value and interest from that which results from the testing of hypotheses without previous deduction.

The psychology of deduction may then well be characterized as the psychology of the *Gedanken-experiment*. The peculiarity of the experimental processes in question is that whether we use symbols, or diagrams, or mental images, our reasoning depends upon the fact that the

objects in question are wholly under our control, so that in dealing with them we have no "course of experience," to use Charles Peirce's phrase, that is, no series of experiences which we have passively to await to see what they are, but are guided wholly by our own control, and are dealing wholly with objects which are what we make them. A given set of premises we construct in terms of symbols, diagrams, or figures, hereby expressing the meaning of these premises. Our deduction consists of the reading of this meaning from a new point of view. The fecundity of the process depends upon our power to combine at pleasure various constructions in various permitted orders and syntheses. The precise relation between such arbitrary objects, and the objects of ordinary experience, forms a topic of almost inexhaustible interest to the student both of logic and of the mental processes concerned.

I have thus indicated that the problems of the psychology of deduction have thus far hardly been attacked, mainly because psychologists have usually been so little interested in live deduction as it exists in mathematical science. So long as the myth still exists in text-books, that deduction is adequately to be represented by the form of the syllogism and the interpretation of that form which Professor Pillsbury cites and uses; so long as it is imagined that deduction merely lets out of the bag the cat that has already been put in it, our logic will languish and our psychology of reasoning will fail to fulfil the purposes of pragmatism or of any other doctrine of the reasoning process. So long as it is supposed that the main purpose of deduction is to produce belief in the conclusions, the psychology of certain of the most important human thinking processes must be lost. As a fact all tolerance, all considerateness in advance of action, all deliberate working out of ideal consequences of modes of behavior concerning which we deliberate,—all such processes would be impossible. A great deal of toleration depends upon seeing how my opponent's conclusions are related to his premises, although I may have no belief either in his premises or in his conclusions. The process of deduction, in case of a practical deliberation concerning what it is best to do, helps us because we thereby learn in advance what *would* be the case *if* so and so were done, even if we ourselves have no tendency whatever as yet to decide in favor of the hypothetical course of procedure.

It seems to me then that the fecundity of the deductive process, the essence of the ideal experiment, and the genuine use of deduction, where it is not intended to produce belief but to give us insight into a connection of premises and conclusion, should form the topic of psychological studies such as thus far have attracted small attention.

VI

Some of the studies that I thus suggest may be of a nature to be treated by the methods of experimental psychology proper. I do not see why the psychological process of solving deductive problems that really illustrate the fecundity of deduction should not be, in certain cases, proper objects for detailed introspection. Let me mention a few possible cases. The one-sided strip of paper and a considerable number of related geometrical forms, may be made the topic of more or less direct experimental inquiry. Trained observers might undertake to solve such problems, namely, as deductive problems proper, that is, as problems of working out what conclusions follow from what premises. The deductive process proper could be separated in such cases from the special empirical materials used. And if the process is brief enough, or can be sufficiently well divided into stages to be the subject of introspection, there is much that is new to discover.

Let me mention another case of an extremely simple process of deduction of a type of which elementary mathematics is full, the process being one that involves a genuine ideal experiment, and a genuine deduction. Almost anybody knows that if the sum of the digits of a number is divisible by nine, the number is divisible by nine, and conversely. Now let the psychological student be asked, if he does not already know the solution of the problem, *Why,* granting the ordinary principles of number, the numbers expressed in any decadic system must have this property. Let the ideal construction by which the problem is solved in a given case be a topic of introspection. The result could easily throw a light upon the psychology of reasoning which no discussion of the misused syllogism could possibly produce.

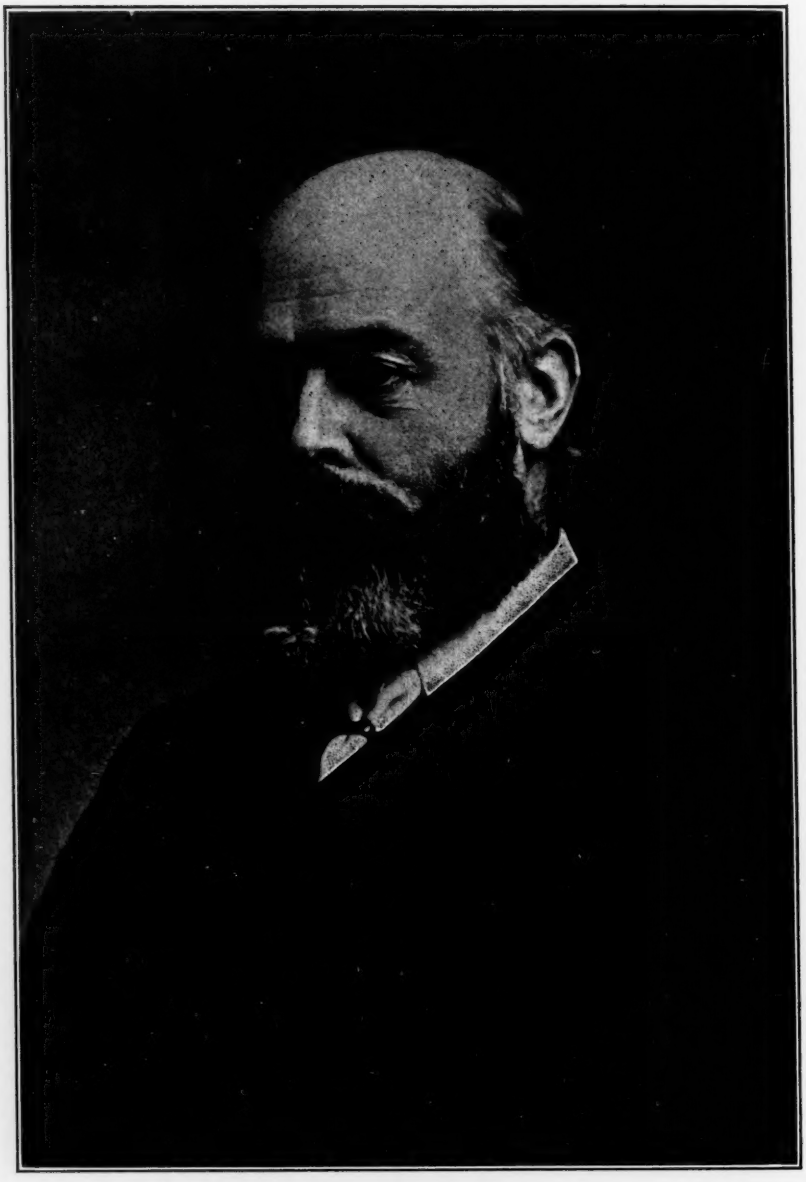
But the syllogism itself does indeed involve deductive processes that have a genuine fecundity. Mrs. Ladd-Franklin's theory of the syllogism, briefly restated by her in Baldwin's "Dictionary" and elsewhere, involves a deductive use of a construction which almost any psychologist can grasp with comparatively little trouble. The nature of the proof of the identity of the ordinary syllogism with Mrs. Ladd-Franklin's reconstruction, can be grasped by a process probably too complex to admit of any strictly experimental control. Yet if one once becomes familiar with this process and with repeated operations of it under controlled conditions, he would have material for the psychology of deduction.

There is another very fascinating problem in the psychology of deduction which has been almost wholly neglected. In my address before the Psychological Association years ago I called attention to the psychology of order as a problem still awaiting discussion. So far as I know, the problem has been little considered by psychologists since that time. But here is an aspect which presents curious phenomena. The

relations "such as," "greater than," "to the right of," "to the left of," are transitive. That is, they follow James's axiom of skipped intermediaries. Now all those serial relations that can be expressed in these transitive dyadic relations can also be expressed in terms of the formally triadic relation "between." Thus, let *A, B, C, D* be four objects in a row. I can say, "*B* is to the right of *A, C* is to the right of *B*." I can conclude that *C* is to the right of *A*. And then I can define the relations of order in question. Now it is very easy to see that if *B* is to the right of *A* and *C* is to the right of *B, C* must be to the right of *A* so long as one interprets the relations of right and left as we ordinarily do. But suppose I give you the premises, "*B* is between *A* and *C, C* is between *A* and *D*," and ask you what follows. The conclusion is decidedly hard for most minds to work out. In other words, the triadic relations have a psychological difficulty which we do not feel in the case of the transitive dyadic relations, although we can express equivalent facts in both terms. The difference in question is hardly due to the fact that a set of three objects is more complicated to grasp than a set of two. For a little exercise in attempting to reason in terms of "between," as the geometers often do, will show that the psychological difficulty is out of all proportion to the numerical difference between two and three. The grounds for the difference in difficulty are presumably statable only in psycho-physical terms. But the matter is one for psychological research, and should be undertaken.

Over against these problems of the psychology of deduction which are possibly capable of a more or less direct experimental research, there are vast numbers of problems of deduction which can be attacked more indirectly, some of them by following the records of formation of new habits, some of them by means of more or less exact study of social processes. There exists, for instance, an indefinite range of possibilities for the study of the psychology of the arithmetical processes by a device which, so far as I know, has still been very little used, although I have repeatedly recommended it to students of educational psychology. We hear a good deal of effort to make out the details of the process whereby a child gets control of arithmetical computations. Now it is perfectly easy for any one to put himself near to the beginning of practical arithmetic and into a place where he has to learn very many of his habits as a computer over again, under conditions that will admit of a pretty careful experimental scrutiny of the way in which the new habits get formed, and which will enable us to make precise records of the growth of the new habits. The device in question consists simply in using, instead of our decadic notation and numeration, a dyadic, triadic, or other such system. Dyadic arithmetic is the simplest of all. In this one uses two digits instead of the digits from 0 to 9, inclusive. That is, one uses only 0 and unity; 1 standing alone will mean unity. If one

uses two digits, the digit on the right will stand for units, the digit on the left for twos. The symbol 10 would now stand for two, the symbol 11 would stand for three, and so on. With the triadic system the places would be used exactly as in our decadic system. In the first place would be the units, in the next place to the left the threes, the third place to the left the nines, the fourth place the twenty-sevens, and so on. Now all numbers could be written in any of these systems. In starting with a new system, one could begin to perform additions, subtractions, multiplications and divisions, as with the decadic system. The possibility of an endless range of experiments, with mature persons, who, while retaining all their present arithmetical knowledge, would be instantly reduced to the position of young children, so far as some of the computations were concerned, all this makes an inquiry into the psychology of simple deductions of this type a very attractive one. Whoever wants to study psychology by becoming a little child has here a place for a wide range of study.



SIR OLIVER LODGE,

Principal of the University of Birmingham, president of the British Association for the Advancement of Science.

THE PROGRESS OF SCIENCE

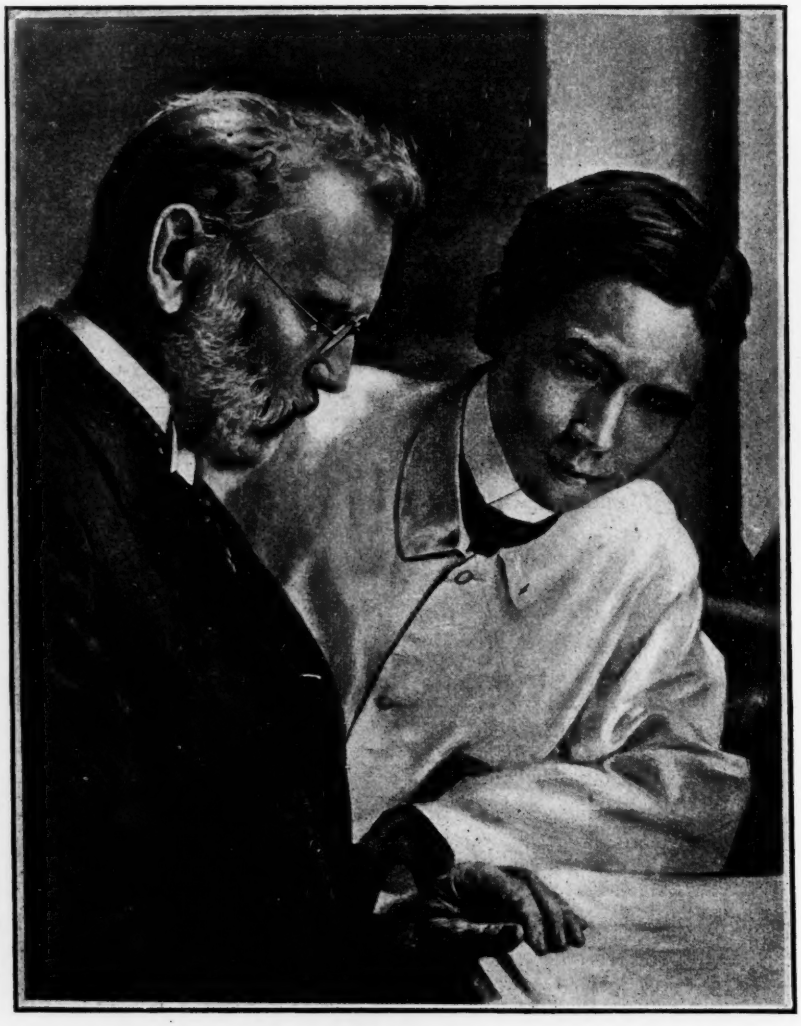
THE PRESIDENTIAL ADDRESS BEFORE THE BRITISH ASSOCIATION

GREAT BRITAIN is able to supply each year for the presidency of its national association for the advancement of science a scientific man of distinction, who can deliver an address in a form interesting to a large audience and likely to attract popular attention. Sir Oliver Lodge, who presided over the Birmingham meeting, was no exception. He is known for his original investigations in experimental physics and at the same time for his wide-reaching speculations. His address combined a statement of recent physical theories, likely to be of interest even to those who can not fully understand them, with some remarks on vitalism and psychical research which are sure to attract wide attention.

Sir Oliver Lodge began his address, which extended to some 20,000 words, by stating that the characteristic of the promising though perturbing period in which we live is rapid progress combined with fundamental scepticism. The subject of his address was "Continuity." He said that the remarkable feature of the present scientific era is the discovery of various kinds of atomism, but he urged that a belief in ultimate continuity is essential to science. The modern tendency is to emphasize the discontinuity or atomic character of everything. Matter has long been atomic and electricity has proved itself to be atomic. The electron is a natural unit of negative electricity, and it may not be long before the unit of positive electricity is also found. Even magnetism is suspected of being atomic and atomic theories of the ether have been invented; biology is said to be becoming atomic through modern ideas on mutation and Mendelian heredity. Sir Oliver Lodge, however, states that he is himself an upholder of ultimate continuity and a firm believer in the ether of space. The ether is a universal connecting medium which binds the universe together and makes it a coherent whole instead of a chaotic collection of independent fragments.

The lecturer then discussed the principle of relativity which had its origin in the famous experiment of two American physicists, Professor Michelson and Professor Morley, concerning the time taken by light to travel to and fro independent of the motion of the earth through space, from which such remarkable conclusions have been deduced by Dr. Einstein and others. Sir Oliver Lodge holds that the dependence of inertia and shape on speed is a genuine discovery, while the principle of relativity seeks to replace these real changes in matter by imaginary changes in time.

There is an emotional appeal in words such as electricity, ether and continuity, and this becomes even greater when we pass to life, free-will and immortality, with which Sir Oliver Lodge deals in the second part of his address. It will be remembered that last year his predecessor in the presidential chair, Professor Shäfer, who is now lecturing in America, defended the mechanistic conception of living bodies. Perhaps a physiologist is more competent than a physicist to decide on which side the weight of the evidence lies, and indeed in the course of his address Sir Oliver Lodge warns us frequently against negative generalizations. In the case of living beings he holds, however, that life introduces an incalculable element. The vagaries of a fire or of a cyclone ought to be pre-



From a photograph in the Illustrated London News.
PROFESSOR EHRLICH AND DR. HATA.

dictable by Laplace's calculator, given the initial positions, velocities and the law of acceleration of the molecules, but no mathematician could calculate the orbit of the common housefly. A spider in the galvanometer of a physicist would introduce a superphysical cause. Still the speaker did not defend vitalism as an appeal to an undefined cause. A living thing obeys the laws of physics like everything else, but it initiates processes and produces results that without it could not have occurred.

A wide public will doubtless be interested in Sir Oliver Lodge's statement of his conviction that occurrences now regarded as occult, not only can be examined and reduced to order by the methods of science, but that evidence so examined has convinced him that memory and affection are not limited to association with matter and that personality persists after bodily death, that evidence goes to prove that discarnate intelligence may interact with us on the material side and that ultimately we may hope to obtain some understanding of the nature of this

larger, perhaps ethereal, existence and of the conditions regulating intercourse across the chasm. The speaker does not repeat the evidence on which he bases his faith, but it certainly has not produced similar conviction on others equally competent to judge.

CHEMIOTHERAPY AND DR. PAUL EHRLICH

IN his address before the recent London International Medical Congress Dr. Paul Ehrlich, director of the Royal Institute for Experimental Therapy at Frankfort-on-Main, reviewed the problems of chemiotherapy. He said that the governing principle is that parasites are only killed by those materials to which they have a certain relationship, which substances are "parasitotropic." In the parasites and in the various organs of the body there are specific chemioreceptors which energetically attract certain fixation groups "somewhat as a magnet attracts iron." It depends on the relationship between the parasitotropism and the organotropism whether a certain disinfectant can be used as a remedy. The only substances that can be considered therapeutic agents are those of which a fraction of the tolerated dose is sufficient to bring about therapeutic effects.

This sounds rather obvious, and in fact Dr. Ehrlich, like Mr. Edison, appears to have accomplished his remarkable results by somewhat empirical methods. This procedure he defends in his address, saying at the outset that the important factors in experimental chemiotherapy are patience, skill, luck and money, and in conclusion: "Considering the enormous number of chemical combinations which must be taken into consideration in the struggle with disease, it will always be a caprice of chance or fortune or of intuition that decides which investigator gets into his hands the substances which turn out to be the best for fighting the disease."

Whether by chance or by intuition, by luck or by genius, Dr. Ehrlich, with the assistance of Dr. Hata and other fellow-workers in his Frankfort laboratory, in salvarsan, or "606," and neosalvarsan, or "914," has discovered drugs with remarkable therapeutic effects. Salvarsan is an arsenical compound with the formula $C_{12}H_{12}N_2O_2As_2$. Its effects on the spirochætes of syphilis are well known, it having already been used in perhaps a million cases in all parts of the world. Cures are sometimes effected by a single injection in the first stages of the disease. It is not so well known that even more striking results have been attained with relapsing fever, the fever immediately subsiding after the injection of salvarsan, and the patients being cured by one injection. The very rare cases of recurrence are also readily curable. Dr. Ehrlich states that it is possible by one single injection of salvarsan to cure frambœsia (yaws), which is caused by spirochætes and is a scourge of the tropics, to cure it completely except in rare cases where unimportant relapses occur. Thus in Surinam a hospital in which over three hundred patients with frambœsia were constantly under treatment was closed and turned to other uses after the introduction of the salvarsan treatment, as one single injection sufficed to cure the disease, and all the patients but two could be discharged.

In the concluding paragraph of his address Dr. Ehrlich said:

The efforts of chemiotherapeutics must be directed as far as possible to fill up the gaps left in our defences, more especially to bring healing to diseases in which the natural powers of the organism are insufficient. And I believe that now definite and sure foundations have been laid for the scientific principles and the method of chemiotherapeutics, the way is visible before us—a way not always easy but yet practicable. In the diseases due to protozoa and spirilla extraordinarily favorable results have already been gained, as I have shown. There are many valuable indications that in a series of other diseases—small-pox, scarlatina, typhus exanthematicus, perhaps also yellow fever, and, above all,

the infectious diseases caused by invisible germs—the prospects of success are brightening. But in contradistinction to the protozoan disorders the ordinary or common bacterial diseases (diseases due to the streptococcus and staphylococcus, *B. coli*, typhoid and dysentery, and above all tuberculosis) will not be vanquished without a hard struggle. Nevertheless, I look forward with full confidence to this development also, and, without being set down as an optimist, will put forward the view that in the next five years we shall have advances of the highest importance to record in this field of research.

SCIENTIFIC ITEMS

WE record with regret the death of Dr. Tempest Anderson, of York, England, known for his publications on earthquakes and volcanoes, and of Dr. Hermann Credner, professor of geology at Leipzig, and director of the Geological Survey of Saxony.

PROFESSOR WILLIAM BATESON, director of the John Innes Horticultural Institute, has been elected president of the British Association for the Advancement of Science for the meeting to be held next year in Australia.—At the meeting of the section of tropical medicine and hygiene of the recent International Medical Congress, Sir Patrick Manson was presented with a gold plaque. It bears his portrait and on the other side an allegorical group representing science triumphing over disease in a tropical landscape.—In honor of Professor John Milne and to continue his work in seismology, it is proposed to collect a fund for endowment. His seismological observatory will probably be moved from the Isle of Wight to Oxford.

THE Permanent International Eugenics Committee, which met in Paris on August 4, decided to hold the next International Congress in New York during September, 1915. Major Leonard Darwin presided, Mrs. Gotto acted as secretary, and the following countries were represented: England (Dr. Edgar Schuster), America (Dr. F. A. Woods), France (M. Lucien March), Germany (Professor A. Ploetz), Italy (Professor C. Gini), Denmark (Dr. S. Hansen), Norway (Dr. J. A. Mjöen).